COMMONWEALTH OF KENTUCKY
DEPARTMENT OF HIGHWAYS
FRANKFORT

HENRY WARD
COMMISSIONER OF HIGHWAYS

September 12, 1966

ADDRESS REPLY TO
DEPARTMENT OF HIGHWAYS
DIVISION OF RESEARCH
132 GRAHAM AVENUE
LEXINGTON, KENTUCKY 40506

H.2.9

MEMORANDUM

TO: W. B. Drake
Assistant Projects Management Engineer
Chairman, Kentucky Highway Research Committee

SUBJECT: Research Report; "Class I Bituminous Mixtures," KYHPR 64-9, HPR 1(1), Part II

The attached report reflects the degree of excellence sought in bituminous concrete pavements in Kentucky during the past several years. In the evolvement of the present state of the art, idealized concepts of mixture design have been dutifully tempered with practical considerations, experience factors, and performance features which may not be altogether apparent from this report alone. In substance, the study has been concerned with aggregate gradations, construction operations, and quality of the pavement surface. The achievement of gradation control in the dust of filler sizes has provided opportunities to further optimize mixture requirements. Permissive blending of sands has enabled the utilization of a broader array of materials. Surface appearance has improved; stability has been increased about four-fold; densities are higher; and enhanced durability already seems evident. From these standpoints, the objectives sought are now seemingly replete. Two factors remain sufficiently ominous and formidable to command further attention.

Whereas each of the aforementioned qualities resulted from purposeful control of fine sand and filler, production samples of Type A mixtures have been found to compact to extreme densities. None of the pavements observed thus far has flushed asphalt to the surface or densified noticeably under traffic; however, these observations do not nullify or negate the possibility that a slight overrun in bitumen content or tack could be rather consequential in this respect. Moreover, the mixture has a minimal capacity to absorb any excess tack material applied in resurfacing work. A good

rule-of-thumb in regard to tack is to deduct an equivalent amount from the design bitumen content, but such control so close to a zero-voids condition requires extreme precision. It seems prudent, therefore, to maintain not less than 3 percent voids as dictated by longstanding criteria. In summation, the minimum percentages of fines as now specified in the Type A gradation seem to be closer to optimum than was realized previously, and some easement of those limits is warranted. There is no known method of precisely predicting the density that will result from a given gradation of aggregate. Control is achieved through trial mixes made on a job-to-job basis. The designer may adjust blending proportions within the framework of the specified gradation limits and, by analyzing trial mixes, establish a suitable job-mix formula. Gradation limits must be sufficiently encompassing to permit such control. Paradoxically, satisfactory as well as unsatisfactory mixtures lie within the same gradation range. The preferred gradation is always represented by the mid-values of the range; and paralleling, uniform gradings are preferred over ricochetting or gap gradings. Nevertheless, considerable freedom must be allowed for job control. Hence, the job-mix formula remains inextricably vital to proper control. It is equally important that the controller have proper means of subtracting or adding dust-size material.

Density (sic, solidity) enhances strength, smoothness, and durability; but it is believed to be somewhat diametrically in opposition to a still nobler quality of a pavement surface--which is skid-resistance. A very solid, smooth surface is conductive to aquaplaning and other wet-weather traction-reducing phenomena. It is known that gritty, porous, sand surfaces definitely offer means of attenuating these effects; but this type of surface texture cannot, practically speaking, be expected from dense bituminous concrete-type pavement courses containing appreciable percentages of limestone coarse aggregates; it can be achieved only by topical applications of sand-type mixtures. Quartz sands incorporated into mixtures such as the Type A are surely beneficial in maintaining wet-weather traction at speeds below the aquaplaning threshold. Although quartz-type sands have been purposefully incorporated in bituminous concrete surfaces built in Kentucky since the early 1950's, all experiences seem to indicate that the ultimate degree of skid-resistance cannot be achieved by this route.

A series of skid-tests made in the spring of 1966, but not included in the report, indicate that the Type A mixture is slightly less skid-resistant than the Type B (modified). This trend

appears to be inversely related to density rather than directly related to quartz sand contents. Of course, the content of quartz sand has been altered considerably also, and the two variables are confounded until more definitive data can be obtained. New surfaces exhibited skid-resistance coefficients (30-to-20 mph deceleration) ranging between 0.65 and 0.55--the mean value being approximately 0.60; with time and usage, these values diminished to 0.55, 0.40, and 0.45, respectively. The influence of specific variables within these ranges is not clear. Values significantly less than 0.40 are adjudged to be critical or unsafe. Worn surfaces not containing polish-resistant sand have, according to previous studies, exhibited coefficients significantly lower than 0.40. It would be desirable, of course, to preserve permanently the same high level of tractive resistance that is exhibited by a new surface; but such aspirations seem too demanding here. The practice of requiring polish-resistant sand in bituminous concrete mixtures is ostensibly sound, and further refinements of current specifications to require quartz or silica contents of not less than 30 percent by weight of total combined aggregate is recommended. The term "Natural Sand" as now employed does not exclude carbonate-type sands and does not provide sufficient assurance that sand so specified will be rich in polish-resistant particles. It is suggested that paragraph 306.2.1 of the Department's 1965 Standard Specifications...be revised as follows:...."Unless otherwise provided on the plans or in the proposals, the mixture used in the final surface course shall contain not less than 30 percent silica (SiO_2) sand by weight of total combined coarse and fine aggregates."

Consideration is invited to the recommendations regarding gradation which are given in the report. Easement of the gradation limits will afford operating latitude and better control of density. Specifically, it is suggested that the gradation limits for the Type A be revised as follows:

Sieve Size	Percent Passing
1/2 - inch	100
3/8 - inch	85-100
No. 4	60-80
No. 8	40-60
No. 16	25-50
No. 50	5-20
No. 100	3-12
No. 200	1.5-6.5

This report consummates the work planned under KYHPR 64-9 and is a final comprehensive issue with respect to HPR 1(1); however, because of compelling interest in the safety aspects of pavement performance and the quality of service desired, both existing and future surfacings will be kept under perpetual observation. A companion study, KYHPR 64-24 (Pavement Slipperiness Studies), will enable continuing surveillance from the standpoint of skid-resistance. Other inquiries relative to the performance of the Class I, Type A surfacing mixture have been provided for under KYHPR 67-44*.

Respectfully submitted,

Jas. H. Havens

Jas. H. Havens
Director of Research
Secretary, Research Committee

JHH:em
cc: Research Committee
A. O. Neiser
R. O. Beauchamp
T. J. Hopgood
R. A. Johnson

Attachment

Research Report

CLASS I BITUMINOUS MIXTURES

KYHPR-64-9; HPR-1(1), Part II

by

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Research Engineer

Division of Research
DEPARTMENT OF HIGHWAYS
Commonwealth of Kentucky

In cooperation with the
BUREAU OF PUBLIC ROADS
U. S. Deaprtment of Commerce

September, 1966

INTRODUCTION

The design of bituminous surface-course mixtures has been undergoing evolution and refinement in Kentucky for several years. The first research work using the Marshall method of analysis and design was conducted in the mid-1940's (1). In 1950, the Department recognized that its surface course mixtures (Class I, Type B) were low in density and deficient in filler-size material (2). A denser-graded surface-course mixture (Class I, Type C) was adopted by amendment to the specifications in 1951 (3,4). The gradation limits of the Type C mixture were similar to the Type A gradation limits analyzed in this present study. Difficulties were experienced in using the mixture (4), and it was abandoned.

In the mid-1950's, the role of aggregate polishing in relation to pavement slipperiness (5,6) was also recognized. Limestone is the predominant aggregate commercially available in the State. Virtually all of the limestone aggregates are susceptible to polishing by traffic and weather. This led the Department to require natural sand as the fine aggregate fraction (50 percent of total) for surface-course mixtures (Class I, Type B) placed on higher traffic-volume roads. The natural sand apparently reduced slickness but introduced other problems. Kentucky's principal sources of natural sands then, primarily Ohio River sand, were deficient in fines (minus No. 50-sieve material). Surface-course mixtures incorporating natural sand as the total fine aggregate typically had high void contents, often in excess of 10 percent, which resulted in early deterioration of the surfaces, i.e. open joints and raveling (7),etc. The stability of those mixtures, of course, was often low. The Standard Specifications... stipulated no requirements for fines-handling systems, such as "dust-run-arounds" or mineral-filler feeders; and only a few contractors had the equipment to properly handle and add mineral-filler-size aggregate. In effect, the desired amount of fines could not be obtained by merely blending limestone coarse aggregate with natural sand.

In 1961, a Class I, Type B surface-course being placed on Interstate 64, Clark County, exhibited low stability and tenderness. A change order was prepared for the project -- which allowed the addition of limestone sand, in a proportion of approximately 20 percent by weight of the total aggregate to supply the needed fines. From the summer of 1961 until April 1963, the Department specified the Type B (Modified) composition limits given in the table below for Interstate surface courses.

Composition Limits, Surface-Course Mixtures, Class I

Sieve Size	Type B	Type B(Modified)	Type C
1/2 - inch	100	100	100
3/8 - inch	85-100	85-100	85-100
No. 4	50-70	55-75	50-70
No. 8	35-50	40-58	35-50
No. 16	20-40	25-48	20-40
No. 50	2-20	5-20	8-20
No. 100	0-10	2-14	5-12
No. 200	0-5	1-7	3-7
Bitumen	4-8	4-8	5.5-8.5

During the 1963 construction season, the modified mixture was specified also for other roads having traffic volumes in excess of 700 vehicles per day. Aggregates were blended in the proportions of: 37 to 43 percent by weight of No. 9 or No. 11, or a blend of No. 9 and No. 11 coarse aggregates; 37 to 43 percent by weight of natural sand, and 17 to 23 percent by weight of crushed limestone or crushed slag sand. All aggregate met the applicable requirements of the 1956 Standard Specifications... for both quality and gradation.

In the same time period, July 1961 to April 1963, the Department was considering rather extensive revisions and updating of the Standard Specifications... Reliable gradation limits were desired for a dense-graded surface-course mixture -- with polish-resistant, natural sand comprising a sizable proporation of the aggregate. Several surfacing projects were let, more-or-less experimentally, to determine gradation requirements which could be met with the aggregates available (8). This work culminated in the adoption of the following gradation limits for Class I, Type A surface, in April 1963.

Sieve Size	Percent Passing
1/2 - inch	100
3/8 - inch	80-100
No. 4	55-75
No. 8	35-60
No. 16	25-50
No. 50	9-21
No. 100	5-14
No. 200	3-7

Coarse aggregates were required to meet both quality and gradation standards; fine aggregates were required to meet quality standards only -- thereby enabling blending of sands to meet gradation requirements. For heavy traffic-volume

roads, the final surface course was required to contain natural sand or conglomerate sand in the proportion of not less than 40 percent of the total combined coarse and fine aggregates. Requirements were also adopted for mineral-filler feeders and dust-return systems to accurately control the higher proportion of fines required in the mixture.

It was anticipated that the revised specifications would be in force during the 1963 construction season; however, they were not put into effect until the 1964 construction season. During 1963, surface-course mixtures for heavy traffic-volume roads were constructed under the requirements of the Class I, Type B (Modified) specification previously outlined. The Type A and Type B (Modified) gradation limits are very nearly identical except for the lower limits below the No. 16 sieve. Graphical representations of the two gradations are shown in Fig. 1 .

GRADATION CHART

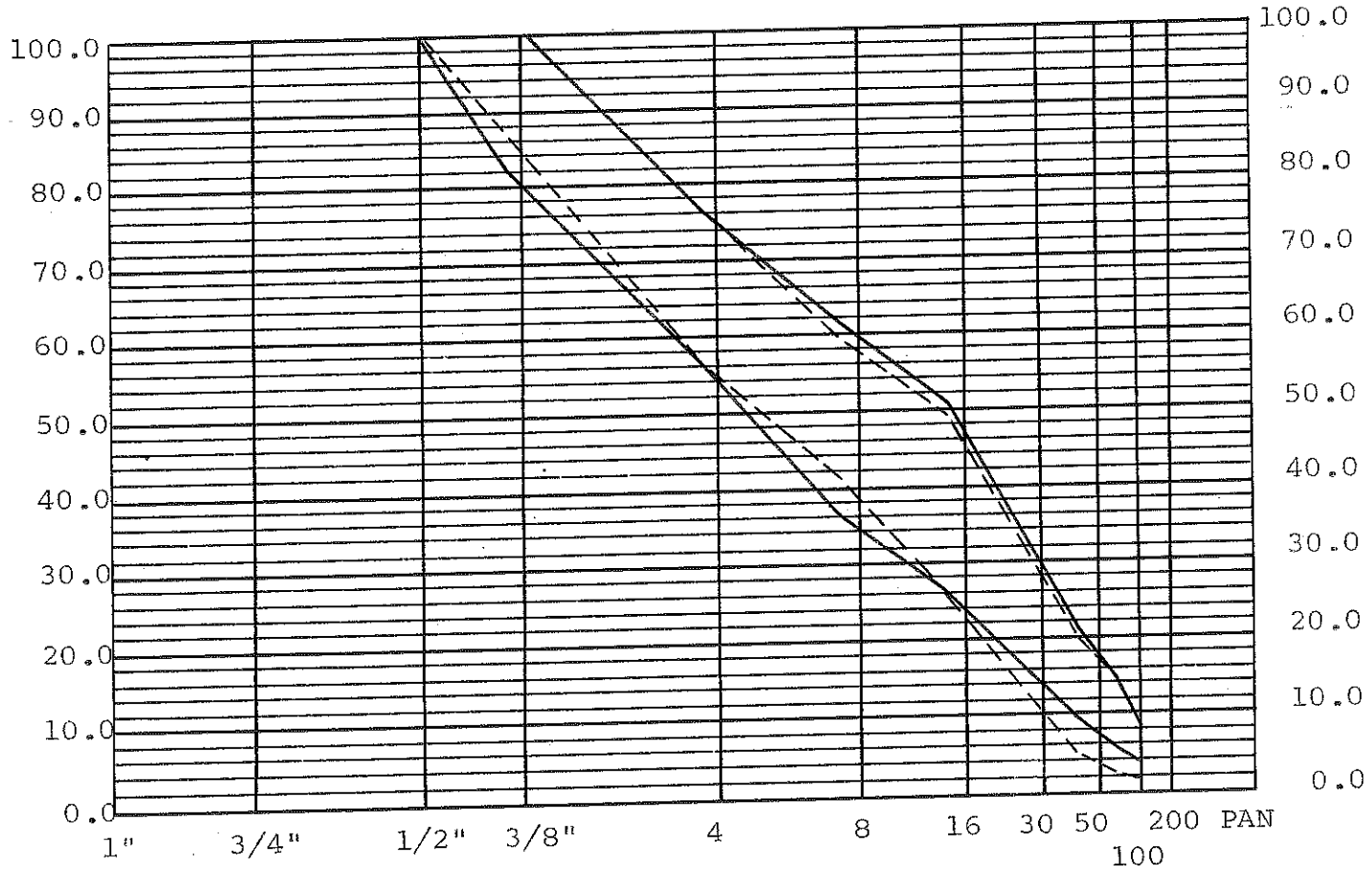


Fig. 1. Class I, Type A gradation limits are shown in solid lines; and the Class I, Type B (Modified) gradation limits are shown in dashed lines.

PROCEDURES

Inasmuch as the objective of this project was to evaluate surface-course mixtures produced under State-wide specifications, it was desired to select projects which were well distributed over the State and to include all of the commonly used coarse aggregate types. The scope of the study was limited to mixtures containing natural sand because these were considered to be the most problematic. Inasmuch as natural sand was required only in mixtures placed on heavy traffic-volume roadways, the selection of projects was somewhat prejudiced toward those areas having heavier traffic patterns. Only projects four lane-miles or more in length were selected for study. Some adjustments had to be made as the study progressed in order to avoid duplicating mixtures made by the same contractor. Often one contractor would be awarded contracts for several projects which met the afore-mentioned selection criteria.

After a project had been selected for study, it was inspected, and samples of the materials were taken for laboratory analysis. The materials were sampled after the plant had been in operation for at least one day. This was done to allow time for the plant to be set-up and operating smoothly. Samples were taken of the mixture, each stockpile of aggregate, and of asphalt cement during the 1963 construction season. During the 1964 and 1965 construction seasons, only the mixture and stockpiled aggregates were sampled.

Samples of the mixtures were taken from the trucks, with a shovel, and were placed in cloth bags. One sample (approximately 50 lbs. of material) was taken from a load, and the sample was a composite of several specimens taken from within the load. Three samples of the mixture were taken on each project. At least one truck was skipped between samplings. The aggregates were sampled at the stockpiles. Two bags, approximately 80 lbs., were taken from various points within the stockpile in an effort to obtain representative samples.

Copies were made of the information available from the Plant Inspector's report forms. Notes were made of any difficulties encountered in producing the mixture. When time allowed, the paving operation was visited; and notes were made of any difficulties encountered in laying the mixture. Particular attention was given to the tack application and to any "pulling" or tearing of the mixture by the paver.

Laboratory Test Procedures

The samples of the mixtures were re-heated to approximately 300°F. Six Marshall specimens were prepared from each of the samples (using 50-blow compaction, Marshall mechanical compactor). The specimens were then tested for stability and flow and analyzed for density and void content. A portion of the re-heated sample was set aside for testing to determine the Measured Maximum Theoretical Specific Gravity as outlined by The Asphalt Institute in "Mix Design Methods for Asphaltic Concrete," second edition, February, 1962. Air-permeability tests were performed on compacted specimens from each of the projects, sampled during 1963.

A minimum of one extraction test was performed on each sample of mixture. If the extraction test results varied widely from the design asphalt content, a second test was performed. The extracted aggregate from each sample was tested for gradation.

Samples of the stockpile aggreates were tested for gradation, ASTM, bulk, oven-dry, specific gravity, and water absorption. Based on the stockpile gradations and the gradation of the extracted aggregate, calculations were made to determine the proportions of each stockpile aggregate used in the mixture.

A Marshall design was performed, using the sampled aggregates in the proportions calculated, to determine the optimum asphalt content for each project and to determine the effects re-heating had on the mixture properties.

Routine laboratory acceptance tests were performed on asphalt cements sampled during the 1963 construction season. This phase of the testing was abandoned in 1964 and 1965.

ANALYSIS OF TEST RESULTS

During 1963, eighteen Type B (Modified) surfacing projects were sampled, and the mixtures were anlayzed in the laboratory. Limestone was the coarse aggregate in fifteen, gravel in two, and slag in one. During 1964 and 1965, thirty Type A, surfacing projects were sampled and analyzed. Thirteen projects were sampled in 1964; limestone was the coarse aggregate in nine, gravel in three, and slag in one. Seventeen projects were sampled in 1965; limestone was the coarse aggregate in thirteen, gravel in three, and limestone was the total aggregate in one.

Descriptive data are shown on a project-by-project basis in Appendix I. The results of each of the individual laboratory tests are summarized and tabulated by each mixture type in Appendix II.

Gradation of Extracted Aggregate

The following are the average and median, extracted gradations for mixtures sampled from 14, Type B (Modified), surfacing projects incorporating limestone coarse aggregates and natural (river and pit) sand and limestone sand fine aggregates:

Sieve Size	Percent Passing	
	Average	Median
1/2 - inch	100	100
3/8 - inch	95.0	95.1
No. 4	69.7	70.0
No. 8	50.9	51.5
No. 16	39.4	39.6
No. 50	10.2	10.5
No. 100	4.8	4.5
No. 200	3.2	3.0

Shown in Fig. 2 are the gradation limits, the median gradation, and (shaded in) the range of the gradations for the fourteen projects. The range and median gradation are well within the gradation limits -- indicating that for these fourteen projects the specification gradation limits were met with little difficulty. The mixtures incorporating gravel and slag coarse aggregates also met the gradation limits.

It appears that, on the average, the limestone and natural sand aggregates were blended in the proportions stipulated by the Type B (Modified) specification. The following gradation results when the average stockpile gradation for each

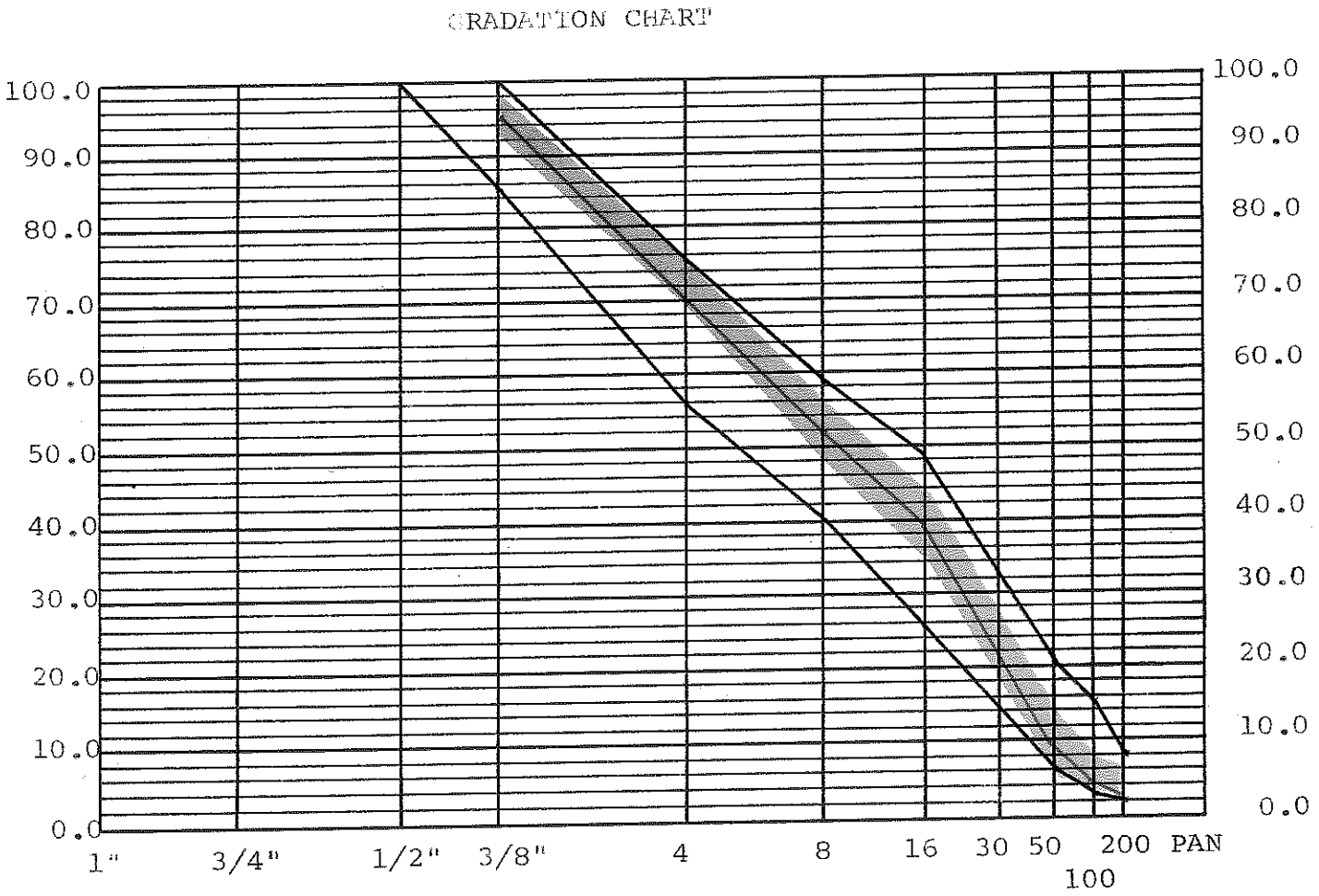
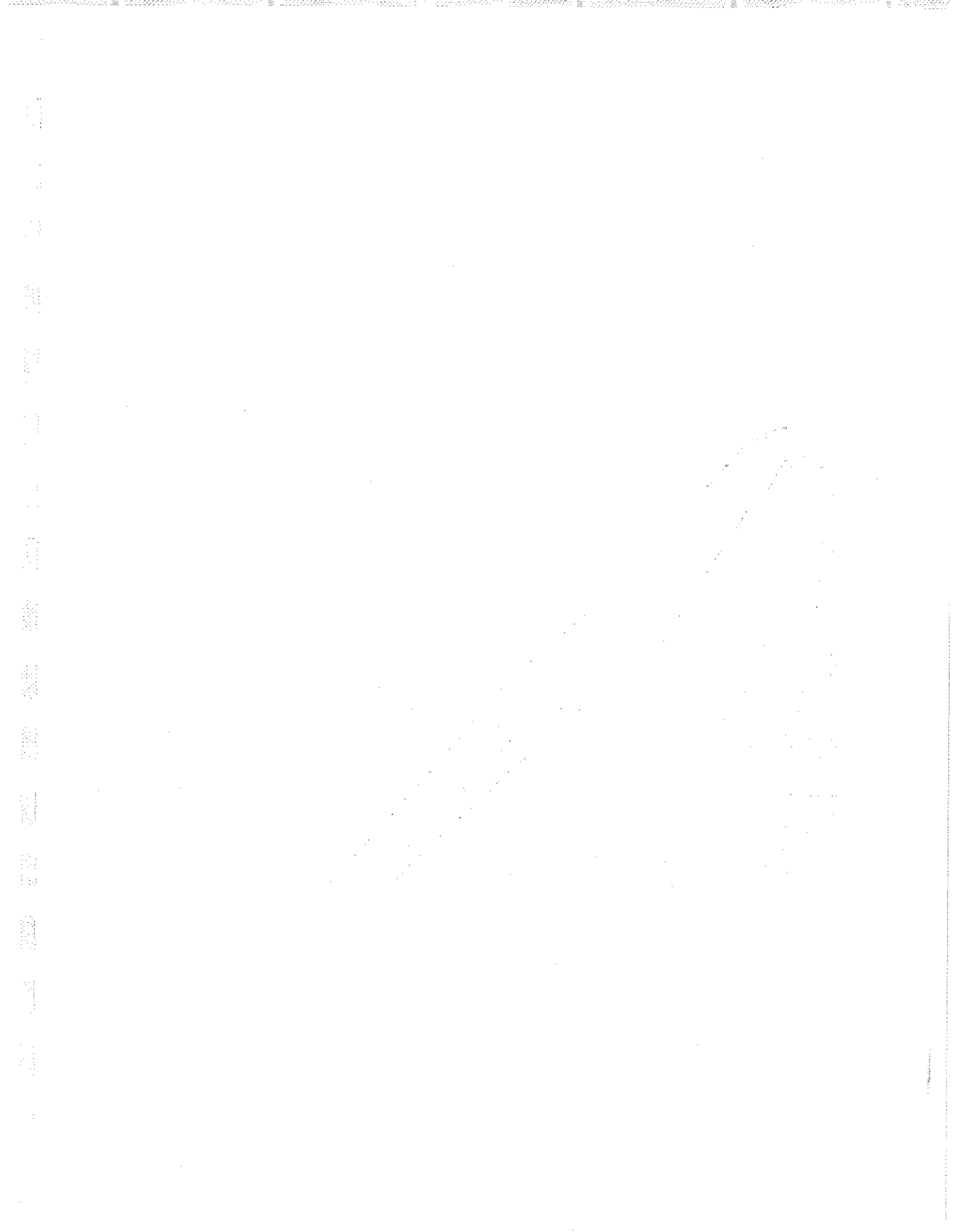


Fig. 2. The Class I, Type B (Modified) gradation limits are shown in black lines. The median gradation of the fourteen projects is shown in red, and the range of gradations for the projects is shaded.



aggregate type is combined in the proportions stipulated by the specification:

Sieve Size	Percent Passing
1/2 - inch	100
3/8 - inch	94.2
No. 4	69.5
No. 8	53.3
No. 16	40.8
No. 50	11.1
No. 100	4.2
No. 200	2.6

One project (SP 60-18, Knott County) involved the use of a crushed, fine-grained, silica sand in lieu of natural sand. The silica sand was a "short-graded" material which had been commercially used as a glass sand. The gradation of the extracted mixture sampled from this project failed the upper specification limit on the No. 16 sieve.

The following are the average and median, extracted gradations for mixtures sampled from twenty-one, Type A, surfacing projects incorporating limestone coarse aggregates and natural sand and limestone sand fine aggregates:

Sieve Size	Percent Passing	
	Average	Median
1/2 - inch	100	100
3/8 - inch	96.1	96.2
No. 4	70.2	70.9
No. 8	52.4	52.7
No. 16	40.2	40.7
No. 50	13.9	13.7
No. 100	7.0	7.1
No. 200	4.7	4.8

From these data, it appears that the Type A gradation requirements were met with little difficulty; however, a closer examination of the individual average gradations for all thirty projects sampled will show that seven projects were outside the limits at one or more points. The median gradation, the gradation limits, and the range of the individual gradations for twenty-one projects containing limestone and natural sand aggregates are shown in Fig. 3. A frequency distribution of the percents passing each screen reveals that for many of the thirty, Type A projects sampled the lower gradation limit is often marginal or out of limits on the No. 50, No. 100, and No. 200 sieves (Fig. 4). This fact is confirmed somewhat by the same distribution

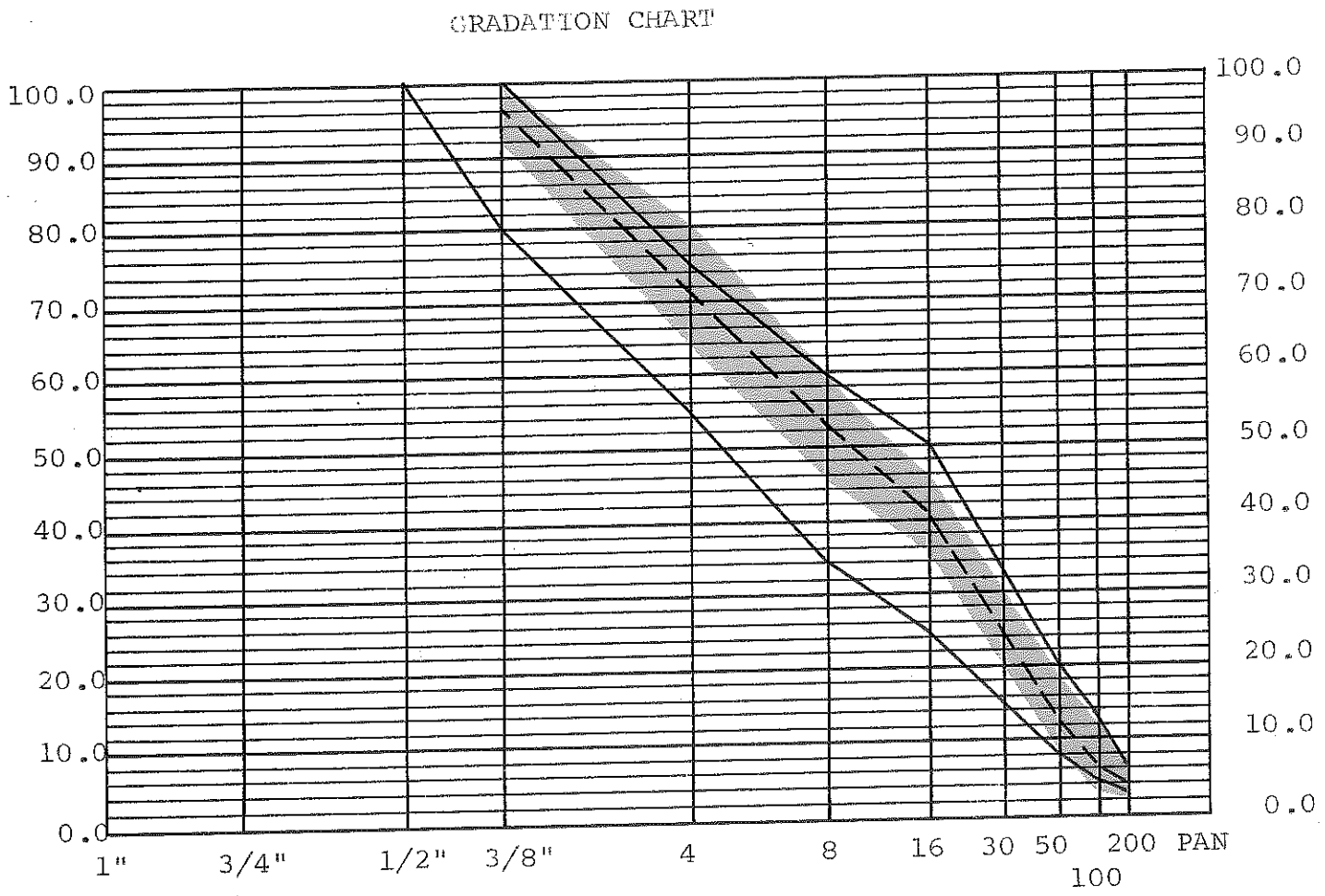


Fig. 3. The Class I, Type A, gradation limits are shown in black lines. The median gradation for the twenty-one projects is shown as a dashed line, and the range of the gradations is shaded.

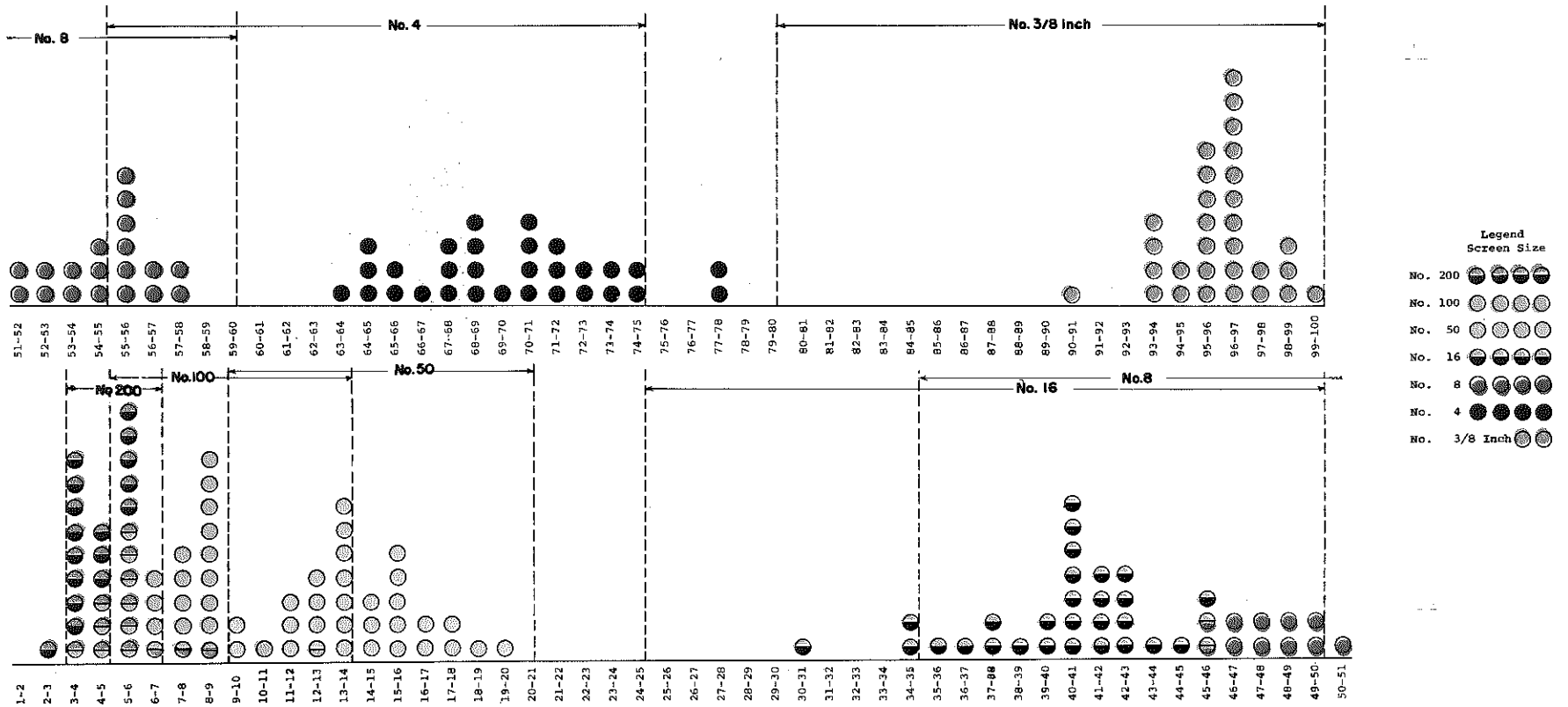


Fig. 4. Frequency Distribution Spectrum for Class I, Type A Surface Gradations.

analysis on the gradations for fifty-five, Type A, surfacing projects containing limestone and natural sand aggregates as reported by the Materials Division.* The following are the average and median, extracted gradations for the fifty-five projects:

Sieve Size	Percent Passing	
	Average	Median
1/2 - inch	100	100
3/8 - inch	94.4	94.8
No. 4	68.2	67.7
No. 8	51.9	52.2
No. 16	41.4	41.0
No. 50	13.0	12.8
No. 100	6.3	6.2
No. 200	4.0	4.0

It is apparent that, for most projects incorporating limestone aggregates, natural sand comprised less than 40 percent by weight of the total aggregate. This computation was based on the gradations of the stockpile aggregates from each project and may be computed also from the average, extracted gradation and the average gradations of the stockpile aggregates for these projects as a group. It appears that the natural sand portion comprised an average of 36 percent by weight of the total aggregate for these projects. On a project-by-project basis, approximately twelve mixtures of the twenty-two contained less than the minimum required proportion of natural sand. The extreme range of the natural sand portion was approximately 28 to 42 percent.

The natural sand requirement, apparently, is not a problem when crushed gravel comprises the coarse aggregate fraction. Six projects, in which crushed gravel was used in the mixture, were sampled; and, in every case, the natural sand was calculated to be in excess of 40 percent.

Asphalt Content by Rotarex Extraction

The asphalt contents as determined in the laboratory by Rotarex extraction are shown in Appendix II for each project. A close examination of these data will show that at least one sample from each of twenty-three of the fourty-eight, Type A and Type B (Modified) project exceeded the specification tolerance ($\pm$ 0.3 percent) on the design asphalt content. Twenty-three percent of the samples tested for asphalt content were outside the tolerance. No pattern of variation could be found; as many

* Memo., Nov. 1, 1965 (Intra-Departmental)

test results were out of tolerance on the low limit as were out of tolerance on the high limit. The method of sampling precludes firm conclusions based on these test results; but, the results do indicate the need for a quality control study of asphalt plants--with special emphasis on the determination and control of asphalt content.

Marshall Test Results, Sampled Mixtures

The following average and median Marshall test results were obtained on the Type B (Modified) mixtures from thirteen surfacing projects containing limestone coarse aggregate and natural sand and limestone fine aggregate:

Average Asphalt Content by Extraction (Percent)		Stability (Lbs.)	Flow (0.01-In.)	Unit Weight (Lbs./Cu.Ft.)	Percent Voids in Agg.	Percent Voids in Mix
5.5	Average	1465	7	146.5	15.4	4.5
	Median	1484	6	145.6	16.4	5.3

The Type B (Modified) mixture, as represented by these averages and as adjudged by the Marshall mix design criteria given below, is very satisfactory from all viewpoints except the flow value.

Marshall Design Criteria for Hot-Mix, Asphaltic Concrete*
(nominal top size aggregate of 3/8-inch and medium traffic)

	Minimum Value	Maximum Value
Stability	500 lbs.	
Flow	0.08-in.	0.18-in.
% Air Voids in Mix	3	5
% Voids in Mineral Aggregate	15.5	

The low flow value is not surprising; surface course mixtures containing a sizable proportion of natural sand have, historically, yielded low flow values. When the total aggregate is limestone the flow value increases appreciably. The stability value for the individual projects ranged from a low of 817 lbs., which is well above the minimum limit of 500 lbs., to a high of 2048 lbs.

*Mix design criteria as published by The Asphalt Institute in "Mix Design Methods for Asphaltic Concrete," Manual Series No. 2, Second Edition, February, 1962.

It may be noted that the average voids in the aggregate, 15.4 percent, is slightly below the minimum figure, 15.5 percent, prescribed in the design criteria. From the tabulation of extracted gradations for these projects, in Appendix II, it may be noted that four of these projects met all the requirements for the Type A surface. If these four projects are deleted, the following average and median Marshall test values are obtained:

Average Asphalt Content by Extraction (Percent)		Stability (Lbs.)	Flow (0.01-In.)	Unit Weight (Lbs./Cu.Ft.)	Percent Voids in Agg.	Percent Voids in Mix
5.65	Average	1331	7	144.9	16.3	5.7
	Median	1331	6	144.9	16.4	6.0

The following average and median Marshall test results were obtained on Type A mixtures containing limestone coarse aggregate and natural sand and limestone fine aggregate from twenty-two surfacing projects:

Average Asphalt Content by Extraction (Percent)		Stability (Lbs.)	Flow (0.01-In.)	Unit Weight (Lbs./Cu.Ft.)	Percent Voids in Agg.	Percent Voids in Mix
5.5	Average	2023	9	147.0	15.0	3.6
	Median	1988	9	147.6	14.5	3.1

In comparing these data to the design criteria, it is apparent that the percent voids in the aggregate is too low. A minimum of 15.5 percent voids in the mineral aggregate, based on the ASTM bulk specific gravity of the aggregate, is required to ensure sufficient space within a compacted paving mixture for the 3 to 5 percent voids needed to prevent flushing or bleeding and to accommodate the bitumen content required for adequate durability under service conditions (9). The VMA (voids in mineral aggregate) is the best indicator of these qualities. This means that the Type A grading, incorporating limestone and natural sand, is too dense--by these standards; but the fact remains that density of the aggregate grading is reflected in the high stability and high unit weight of the mixture.

The following are average and median Marshall test results for Type A mixtures incorporating crushed gravel coarse aggregate and natural sand fine aggregate from six surfacing projects:

Average Asphalt Content by Extraction (Percent)		Stability (Lbs.)	Flow (0.01-In.)	Unit Weight (Lbs./Cu.Ft.)	Percent Voids in Agg.	Percent Voids in Mix
5.7	Average	1383	8	144.4	16.1	4.7
	Median	1339	8	143.7	16.1	4.6

It may be noted that these average data are within the range of the design criteria. One of the projects, RS Group 34(1965), incorporated fly-ash as the mineral filler, and the aggregate density for the project was too high.

Marshall Designs

A Marshall design was performed for each project, using the aggregates sampled from the project. The aggregates were combined in proportions simulating the average extracted gradation of the mixture sampled from each project. This testing enabled determinations of the optimum asphalt content for each project and of any errors introduced through re-heating the production samples.

The average and median Marshall values, at optimum asphalt content, for the Type B(Modified) mixtures containing limestone and natural sand aggregates are as follows:

Average Optimum Asphalt Content (Percent)		Marshall Design Values: Stability (Lbs.)	Flow (0.01-In.)	Unit Weight (Lbs./Cu.Ft.)	Percent Voids in Agg.	Percent Voids in Mix
5.8	Average	1445	7	146.0	15.9	4.2
	Median	1358	7	145.5	16.1	4.5

The average and median Marshall values, at optimum asphalt content, for Type A mixtures containing limestone and natural sand aggregates are as follows:

Average Optimum Asphalt Content (Percent)		Marshall Design Values: Stability (Lbs.)	Flow (0.01-In.)	Unit Weight (Lbs./Cu.Ft.)	Percent Voids in Agg.	Percent Voids in Mix
5.5	Average	1719	8	147.0	14.9	3.4
	Median	1635	8	147.0	14.8	3.3

When these results are compared to the results from the field samples, it may be noted that the density and void figures are in good agreement. The higher stabilities from the field samples indicate that the asphalt cement was hardened as a result of the sampling and re-heating procedures.

The design asphalt content for some projects is set on the basis of experience. Over one-half the asphalt contents set at the plant were within 0.2 percent of the optimum asphalt content as determined by the Marshall test, and eighty-five percent were within 0.5 percent of the optimum determined in the laboratory. In general, the estimated asphalt content was set below the laboratory design asphalt content about as often as it was set above the laboratory design asphalt content. However, on seven projects, the design asphalt contents were set perilously high--as indicated by the void contents of the mixtures sampled in the field. Dense mixtures, such as the Type A, are very sensitive to effects of improper asphalt contents, over-tacking between courses, and errors in batching the aggregates. This sensitivity to asphalt content stresses the importance of performing Marshall designs whenever possible for surfacing projects. It is also very important that the design asphalt content be set by an experienced materials engineer and changed only when he deems it to be advisable. On one project, the materials engineer set the asphalt content at the optimum indicated by the Marshall design, and then the asphalt content was raised 0.4 percent at the insistence of a district official of the Department. This caused the mix to be perilously close to a zero-voids condition. In conjunction with this high asphalt content, a heavy tack coat was used.

It is noted that heavy tack coats were observed on many projects. The purpose of a tack coat is to insure a bond between an old surface and the superimposed new surface. Essential properties of tack coats are that they must be very thin and that they uniformly cover the entire area to be resurfaced (10). In the case of a very densely graded mixture, a thin application of tack is especially important in that any excess tends to migrate upward through the mixture and cause bleeding and instability. On one project, US 25 in Madison County (SP 76-51), the tack was apparently tracked back over the freshly laid mat by heavy traffic and caused the surface to have a glazed finish (Fig. 5). The tack coat was covered with natural sand during construction but much of the sand cover was whipped off by the heavy traffic before paving.

A proper tack coat may be obtained by use of diluted emulsions, types SS-1 or SS-1h, or cut-back asphalts such as RC-0 or RC-1. The tack should not be used in excess of 0.05 gallon of base asphalt per square yard; this is equivalent to a full paint coat. Every effort should be made to keep traffic off the tack coats and to apply no more tack coat than is necessary for one day's operation.

Fig. 5. US 25 Madison County (SP 76-51). Note the glazed appearance in the wheel-tracks beginning at the lateral joint. Traffic was maintained on the project during construction, and tack was tracked over much of the finished surface. Traffic volume on the roadway is in excess of 10,000 vehicles per day.

Air-Permeability Tests on Type B(Modified) Mixtures

Laboratory air-permeability tests were performed on Marshall specimens prepared from the Type B(Modified) mixtures sampled in the field during 1963. The tests were performed with a Soiltest Asphalt Paving Meter (Model AP 400-A). Inasmuch as all of the Type B(Modified) specimens were virtually impermeable to air, at the testing pressures, this phase of the testing was discontinued.

Tests on Asphalt Cements

During 1963, samples of asphalt cements were obtained from the various Type B (Modified) projects. The results of the laboratory tests performed on the asphalt cements are shown in Appendix II. This phase of the testing was abandoned after the 1963 construction season.

DISCUSSION AND RECOMMENDATIONS

In analyzing the results of this study it should be clearly kept in mind that the study is an evaluation of surface mixtures produced under two gradation specifications which differ only in the lower gradation limit below the No. 16 sieve. When the median and average, extracted gradations for the Type B (Modified) and Type A mixtures containing limestone and natural sand aggregates are compared on a percent-passing-and-retained basis, the following results:

Passing Sieve Size	Retained Sieve Size	Median Type B (Modified)	Median Type A	Average Type B (Modified)	Average Type A
1/2-in.	3/8-in.	4.9	3.8	5.0	3.9
3/8-in.	No. 4	25.1	25.3	25.3	25.9
No. 4	No. 8	18.5	18.2	18.8	17.8
No. 8	No. 16	11.9	12.0	11.5	12.2
No. 16	No. 50	29.1	27.0	29.2	26.3
No. 50	No. 100	6.0	6.6	5.4	6.9
No. 100	No. 200	1.5	2.3	1.6	2.3
No. 200	PAN	3.0	4.8	3.2	4.7

From this comparison it is apparent that the only difference of any magnitude is in the dust sizes (minus No. 16 sieve material).

The median gradations for the Type B (Modified) and the Type A mixtures which contained limestone and natural sand fine aggregates are shown in Figure 6. A maximum density line is also drawn on the chart from a theoretical, zero-percent passing a minimum sieve size to 100-percent passing the effective maximum size. For gradations of the same type of aggregate, those which plot closest to the line will usually represent gradations yielding the lowest voids in the compacted mixture. This chart and its derivation are explained in "Aggregate Gradation for Highways", issued by the Bureau of Public Roads in May, 1962, and in reference (11). It may be noted that both median gradations plot very close to the maximum density line for the No. 16 and coarser sieves; but, for the sieves finer than the No. 16, the Type A median gradation plots closest to the maximum density line. This indicates that the higher density of the Type A mixture results from the larger proportion of minus No. 16 material.

The laboratory Marshall analysis of mixtures produced under the Type A specification requirements indicate that on

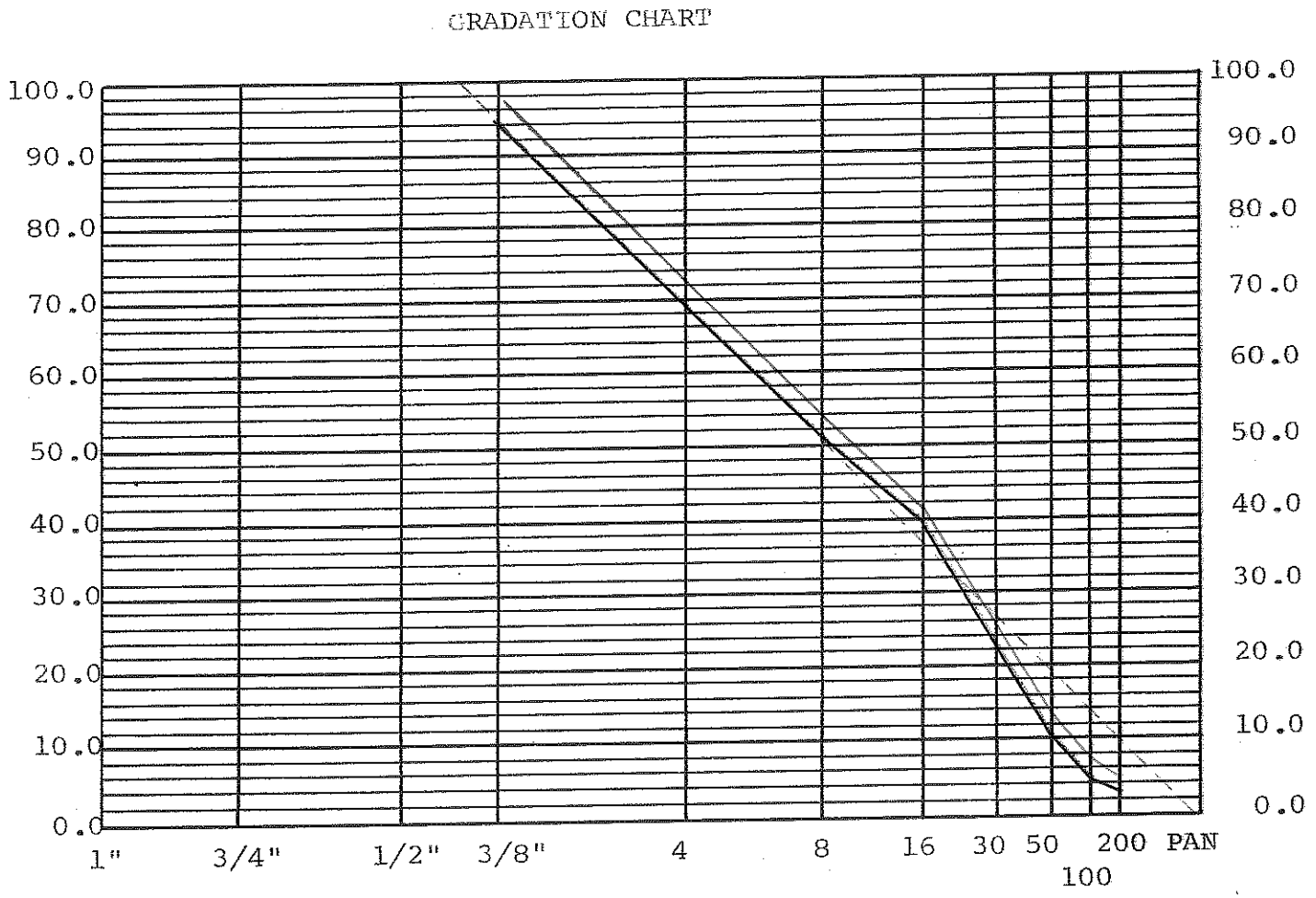


Fig. 6. The median gradation for the Type B (Modified) is shown in black, and the median gradation for the Type A is shown in red. The theoretical maximum density gradation is shown as a dashed blue line.

the average the density of the mixture is too high to satisfy accepted mix design criteria. During the 1964 and 1965 construction seasons, several reports were received of difficulties encountered in laying the mixture. In most instances, the trouble was described as rough or pulled areas left by the paver screed, which the rollers could not smooth out. These problems in paving were probably aggravated by the higher dust content and the resulting high density and toughness of the mixture. Ordinarily the dust content might be lowered at the mixing plant by reducing the proportion of fine aggregate at the cold-feed or by removing all or a portion of the dust by means of the dust collector; but, for the Type A mixtures, this would often not be possible inasmuch as the grading is often too near the lower grading limit on the No. 50, No. 100, and No. 200 sieves.

Laboratory analysis of mixtures produced under the Type B (Modified) gradation limits indicate that the average Marshall properties of these mixtures satisfy the design criteria; however, it should be clearly understood that very nearly all the mixtures, both the Type A and Type B (Modified), included in this study will meet the Type B (Modified) gradation limits. This means also that overly dense mixtures can be produced within the Type B (Modified) gradation limits.

It is recommended that the Type A gradation limits be amended to agree more closely with the Type B (Modified) gradation limits. As pointed out, this measure will not in itself insure the production of good surface course mixtures but will provide limits within which the gradation may be adjusted at the plant to yield a satisfactory mixture. The requirements made in the 1965 Standard Specifications... with regard to mineral filler feeders and dust-return systems have made it possible to control the critical dust fraction at the plant. The requirement that natural sand comprise a minimum of 40 percent of the total combined aggregate is not sufficiently discriminative with respect to silica and should be dissolved and replaced with more discrete terms.

It is also recommended that Marshall designs be performed preparatory to surfacing. A mix design method, such as the Marshall, is the surest way of determining proper proportions of aggregate and asphalt. This measure would minimize the chances of producing mixtures which will become slick as a result of high asphalt content after a period of time under traffic. It is also recommended that greater control and care be excerised in the application of tacking materials.

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APPENDIX I

Project No : Marshall County, SP GROUP 25(1963)

Roads: SP 79-13, Benton-Paducah (US 68) Rd., from US 641 to the McCracken County Line, 10.108 miles.

SP 79-93, Benton-Eggner's Ferry (US 68) Rd., from KY 408 extending southeasterly 3.000 miles.

Tonnage: 21,410

Unit Bid: $4.73

Contractor: Roads Inc., Paducah, Kentucky

Plant Location: Roads Inc., Paducah, Kentucky

Plant Description: Standard Steel (5000 lb.)

Data Sampled: August 15, 1963

Materials Source: No. 9 Limestone - Three Rivers Company
Limestone Sand - Three Rivers Company
Natural Sand - Harry Berry, Inc.
Asphalt Cement (PAC-5) - Delta Refining Co.

Mixture Composition: 40% No. 9 Limestone
40% Natural Sand
20% Limestone Sand
5.7% Asphalt Cement (PAC-5)

Comments: The same mixture was used on McCracken County, SP GROUP 26 (1963). Dust returned to bottom of the hot-elevator.

Project No: McCracken County, SP GROUP 9 (1963)

Roads: SP 73-332, Paducah Beltline from Brown St. to Bridge Street, 1.244 mi.

SP 73-352, Paducah Beltline from Broadway along 28 St. to Thompson Ave., 0.500 mi.

SP 73-342, Paducah Beltline, from Park Ave. to 28 St., 0.208 mi.

Tonnage: 6,330

Unit Bid: $5.30

Contractor: Middle West Roads

Plant Location: Lake City, Kentucky

Plant Description: Warren Bros. (4000 lb.)

Date Sampled: August 14, 1963

Materials Source: Limestone-Reed Crushed Stone Co., Lake City, Kentucky
Natural Sand - Federal Materials, Paducah, Kentucky
Asphalt Cement (PAC-5) - Ky. Asphalt Sales (Texaco)

Mixture Composition:

40%	No. 9 Limestone
40%	Natural Sand
20%	Limestone Sand
5.7%	Asphalt Cement (PAC-5)

Comments: Collected dust was returned at the foot of the hot-elevator. Patching was placed on the surface, and a heavy tack coat was applied. The samples of materials were taken while the plant was being "set-up".

Project No: Hopkins-Webster County, SP GROUP 10(1963)

Roads: SP 54-260, the Hopkinsville-Dawson Springs-Providence (KY 109) Rd., from KY 70 at Buelah to the Webster Co. Line, 9.100 miles.

SP 117-229, the Dawson Springs-Providence(KY 109) Rd., from the Hopkins Co. Line to S.C.L. of Providence, 0.437 miles.

Tonnage: 11,890

Unit Bid: $5.97

Contractor: Dixie Pavers, Hopkinsville, Ky.

Plant Location: Hopkinsville Stone Co.

Plant Description: Hetherington-Berner(4000 lb) Semi-Automatic

Date Sampled: August 13, 1963

Materials Source: Limestone - Hopkinsville Stone Company
Natural Sand - Bedford Nugent, Henderson,Ky.
Asphalt Cement (PAC-5) - Lion Oil Company

Mixture Composition:

40%	No. 9 Limestone
40%	Natural Sand
20%	Limestone Sand
5.8%	Asphalt Cement (PAC-5)

Comments: Two pavers were used to obtain a hot joint. The tack application was light, but tack was tracked over the freshly laid course by traffic. Patching (leveling) was necessary on much of the road.

Project No: Warren County, SP GROUP 34(1963)

Roads: SP 114-388, State St. in Bowling Green, from 12th St. to First, 1.047 miles.

SP 114-68, College and First Streets, in Bowling Green, from Main St. to New Bridge over Barren River, 0.985 miles.

SP 114-188, The Bowling Green-Franklin Rd., in Bowling Green, from Main St. along college, 13th, State, 14th and Chestnut Sts. to 17th St., 1.324 miles.

Tonnage: 4,085

Unit Bid: $9.75

Contractor: R.E. Gaddie, Bowling Green, Ky.

Plant Location: Gary Bros. Quarry, Bowling Green, Ky.

Plant Description: Hetherington-Berner (4000 lb)

Date Sampled: September 18, 1963

Materials Source: Limestone - Gary Bros. Quarry, Bowling Green
Natural Sand - Owensboro Sand and Gravel
Asphalt Cement (PAC-5) - Lion Oil Co.

Mixture Composition: 40% No. 9 Limestone
40% Natural Sand
20% Limestone Sand
5.5% Asphalt Cement (PAC-5)

Comments: Samples of materials were taken while the plant was being "set-up". Plant Inspectors' initial extraction tests indicated the asphalt content was tending to run high. Dust was returned to a separate bin and weighed into the mix.
Plant Screens; 9/16-in., 1/4-in., 1/8-in.
Proportions; 30% Coarse, 20% Intermediate, 47% Fine.

Project No: Taylor County, SP 109-48

Roads: Campbellsville-Liberty Rd., Ky. 70, from 6.684 miles east of East City Limit of Campbellsville to the Casey County Line, 13.428 miles.

Tonnage: 12,900

Unit Bid: $8.24

Contractor: Whitlock & Long Construction Co., Lebanon, Ky.

Plant Location: Nally & Gibson Quarry, South of Greensburg

Plant Description: Barber-Greene (80 ton/hr.)

Date Sampled: August 21, 1963

Materials Source: Limestone - Nally & Gibson Quarry
Natural Sand - Louisville Sand & Gravel
Asphalt Cement (PAC-5) - Ashland Oil and Refining Co.

Mixture Composition:
40% No. 9 Limestone
40% Natural Sand
20% Limestone Sand
5.7% Asphalt Cement (PAC-5)

Comments: The tack application was not uniform. One paver was being used. The compacted mat appeared to be "open" and "tender" as compared to other projects investigated.

Project No: Jefferson County, RH GROUP 4(1963)

Roads: RH 1017-A, Old Henry Road, from English Station Rd. to the Evergreen Rd., 1.200 miles.

RH 1087-A, Lyndon Lane Road, from the Shelbyville Rd. to the LaGrange Rd., 0.900 miles.

Tonnage: 8,275

Unit Bid: $7.10

Contractor: Murray Co., Avoca, Ky.

Plant Location: Avoca, Kentucky

Plant Description: Cedarapids Portable (2500 lb.)

Date Sampled: August 6, 1963

Materials Source: Limestone - Jefferson Co. Stone
Natural Sand - Nugent Sand Co., Louisville,Ky.
Asphalt Cement (PAC-5) - Sinclair Refining Co.

Mixture Composition: 40% No. 9 Limestone
40% Natural Sand
20% Limestone Sand
5.6% Asphalt Cement (PAC-5)

Comments: Only a brief inspection was made. The mixture had a fine texture and a good appearance.

Project No: Jefferson County, RH GROUP 4(1963)

Roads: RH 1064-A, Watterson Trail Road, from Bardstown Road East to Jeffersontown City Limit, 3.000 miles.

RH 1065-A, Fern Creek Road, from Bardstown Road South to the Buelah Church Road, 8.00 miles.

RH 1074-A, Six-Mile Lane Road, from Bardstown Road to Fredericks Lane Road, 1.500 miles.

Tonnage: 8,275

Unit Bid: $5.25

Contractor: Murray Company, Fern Creek Plant

Plant Location: Fern Creek

Plant Description: Simplicity (4000 lb.)

Date Sampled: August 15, 1963

Materials Source: Limestone- Falls City Stone Co.
Natural Sand - Louisville Sand & Gravel
Asphalt Cement (PAC-5) - Sinclair Refining Co.

Mixture Composition:

40%	No. 9 Limestone
40%	Natural Sand
20%	Limestone Sand
5.6%	Asphalt Cement (PAC-5)

Comments: Paving operation was not inspected. Dust was returned to the bottom of the hot-elevator.

Project No: Jefferson County, RH GROUPS 5&6(1963)

Roads: RH 1127-A, Minors Lane Rd., from South Park Rd. to Edelin Drive, 0.900 mi.

RH 1139-A, Crittenden Dr. Rd., from 800ft. south of Louisville city limits to Grade Lane Rd., 1.600 mi.

RH 1147-A, National Turnpike Rd., from Outerloop to South Park Rd., 3.100 mi.

RH 1166-A, Ashby Lane, from Lower River Rd., to Dixie Highway, 1.300 mi.

RH 1185-A, Cane Run Road, from 200ft. north of Kramers Lane to Millers Orchard, 3.800 mi.

RH 1185-A, Lower River Rd., from Ashby Lane to Moorman Rd., 1.1 mi.

Tonnage: 16,930

Unit Bid: $5.52

Contractor: Middle West Roads, Louisville, Ky.

Plant Location: Strawberry Lane, Louisville, Ky.

Plant Description: Cedarapids (4000 lb.)

Date Sampled: September 27, 1963

Source of Materials: Limestone - Lambert Bros. at Fern Creek, Ky.
Natural Sand - Middle West Rds. Louisville, Ky.
Asphalt Cement (PAC-5) - Ashland Oil Co.

Mixture Composition: 40% No. 9 Limestone
40% Natural Sand
20% Limestone Sand
5.5% Asphalt Cement (PAC-5)

Comments: Dust returned at the hot-elevator.

Project No: Fayette County, I-75-4(15) 98

Roads: The Covington-Lexington-Tennessee State Line Road from the north end of Clays Ferry Bridge to Approx. 0.25 mi. south of Grimes Mill Road -2.471 mi.

Tonnage: 6000

Unit Bid:

Contractor: Lehman-Meade, Lexington, Kentucky

Plant Location: Plant No. 4, Lexington, Kentucky

Plant Description: Standard Steel Batch (4000 lb.)

Date Sampled: July 30, 1963

Materials Source: No. 9 Limestone - Central Rock Co.
Limestone Sand - Central Rock Co.
Natural Sand - D.W. & G. Co. Frankfort, Ky.
Asphalt Cement (PAC-5) - Sinclair

Mixture Composition:
40% Natural Sand
40% No. 9 Limestone
20% Limestone Sand
5.8% Asphalt Cement (PAC-5)

Comments: Materials Division Marshall design optimum 6.0% asphalt. Material for another section of I-75 and for a Bourbon County Project (SP9-19) was produced at this same plant. At the time of sampling the material was running high on the No. 4 screen. Plant Screens; 9/16-in., 1/4-in., 1/8-in. Proportions; 30% Coarse, 20% Intermediate, 50% Fine.

Project No: Carter County, SP GROUP 21(1963)

Road: Grayson-Ashland (US. 60) Rd. from the Boyd County Line to East City Limit of Grayson - 10.632 miles.

Tonnage: 15,225

Unit Bid: $8.59

Contractor: East Ky. Paving Co. Olive Hill, Kentucky

Plant Location: Olive Hill, Kentucky

Plant Description: Cedarapids (6000 lb.)

Date Sampled: July 19, 1963

Source of Materials: Limestone-Acme Stone Co.,Olive Hill,Ky.
Natural Sand - Middle States Concrete Co.
Ashland, Kentucky
Asphalt Cement (PAC-5)-Ashland Oil

Mixture Composition:
40% No. 9 Limestone
40% Natural Sand
20% Limestone Sand
5.6% Asphalt Cement (PAC-5)

Comments: The collected dust was weighed into the mix. The draft on the collector was too strong and a large amount of dust was lost into the wet collector. The tack application was heavy. A light cover of No.9 stone was placed over the tack to prevent "pick-up" by traffic. Traffic was blocked off the freshly laid mat for 1/2 day.

Project No: Nicholas County, SP 91-139

Road: US 68 from 1.414 Mi. Southwest of Ellisville to the Fleming County Line - 6.535 Mi.

Tonnage: 6,675

Unit Bid: $8.90

Contractor: Carey & Adams Construction Co.

Plant Location: Gorman Quarry on Ky. 11 near Flemingsburg

Plant Description: Hetherington-Berner (2500 lb.)

Date Sampled: August 22, 1963

Materials Source: Limestone - Gorman Quarry, Flemingsburg, Ky.
Natural Sand - Hardymon Co. Maysville, Ky.
Asphalt Cement (PAC-5) - Ashland Oil Co.

Mixture Composition: 40% No. 9 Limestone
40% Natural Sand
20% Limestone Sand
5.6% Asphalt Cement (PAC-5)

Comments: The plant was approximately 23 years old and had no dry collector. The limestone appeared to be soft and to produce a large amount of dust. Tack was tracked over the surface in a few areas.

Project No: Bell County, SP 7-84

Road: Blackmont-Alva Rd. (Ky. 72) from US 119 at Blackmont Bridge to the Harlan Co. Line - 3.415 mi.

Tonnage: 2,875

Unit Bid: $8.75

Contractor: Kentucky - Virginia Stone Co., Middlesboro, Ky.

Plant Location: US 25 E. near Middlesboro

Plant Description: Barber - Greene (150 T/hr)

Date Sampled: August 1, 1963

Materials Source: Limestone - Ky. -Va. Stone, Trent, Va.
Natural Sand - Lousiville Sand and Gravel
Asphalt Cement (PAC-5)-Ashland Oil Company

Mixture Composition:
40% No. 9 Limestone
40% Natural Sand
20% Limestone Sand
5.6% Asphalt Cement (PAC-5)

Comments: Dust was returned to mix at the foot of the hot-elevator. Tack application appeared to be heavy as the surfacing was laid over a fresh binder course. Specimens prepared from the mixture appeared to be more open and lean as compared to other projects sampled.

Project No: Whitley County, SP 118-220-7

Roads: Corbin-Cumberland Falls Rd. from city limit of Corbin to near Youngs Creek- 9.238 miles.

Tonnage: 8,260

Unit Bid: $7.30

Contractor: Cantrill Construction Co.

Plant Location: Medcalf, Ky.

Plant Description: Hetherington - Berner (5000 lb.)

Date Sampled: September 16, 1963

Materials Source: Limestone- Ky. Stone Co. Mullins,Ky.
Natural Sand - Louisville Sand and Gravel
Asphalt Cement (PAC-5)-Ashland Oil Co.

Mixture Composition: 40% No. 9 Limestone
40% Natural Sand
20% Limestone Sand
5.6% Asphalt Cement (PAC-5)

Comments: Dust returned to the hot-elevator.

Project No: Lawrence County, SP GROUP 15(1963)

Roads: SP 64-13, The Louisa-Ashland (US 23) Road from junction of Madison and Main Streets in Louisa to 198.2 ft. southwest of Centerline of C & O R.R. crossing, a distance of 0.739 mile.

SP 64-53, The Louisa - Paintsville (US 23) Road from N.W. Curb Line of Madison Street in Louisa to S.C.L. of Louisa, a distance 0.340 mile.

SP 64-53, The Louisa - Paintsville (US 23) Road from S.C.L. of Louisa extending southerly, 1.878 miles.

Tonnage: 17,070

Unit Bid: $9.21

Contractor: Hinkle Contracting Corporation
(sub-contracted from Adams Construction Company)

Plant Location: US 23 near Catlettsburg

Plant Description: Cedarapids (5000 lb.)

Date Sampled: July 24, 1963

Source of Materials: Limestone - Standard Slag & Stone
Carter City, Kentucky
Natural Sand- Jerries Sand and Gravel
Portsmouth, Ohio
Asphalt Cement (PAC-5) Ashland Oil Co.

Mixture composition: 40% No. 9 Limestone
40% Natural Sand
20% Limestone Sand
5.6% Asphalt Cement (PAC-5)

Comments: The tack application, within the city limits of Louisa, appeared to be too heavy. Dust returned to a separate bin and weighed into the mix. Plant Screens; 9/16-in., 1/4-in., 1/8-in. Proportions; 35% Coarse, 15% Intermediate, 48% Fine, 2% Dust.

Project No: Knott County, SP 60-18

Roads: Hindman-Lackey (Ky. 8) Rd.,from northeast city limit of Hindman to the Floyd Co. Line - 13.980 miles.

Tonnage: 11,765

Unit Bid: $9.68

Contractor: Adams Construction Co.

Plant Location: Burdine, Ky. near Jenkins

Plant Description: Cedarapids (8000 lb.)

Date Sampled: August 1, 1963

Materials Source: Limestone - Levisa Stone Corp.
Jenkins, Ky.
Silica Sand - Silica Sand Corp. of America
(Elkhorn City, Kentucky)
Asphalt Cement (PAC-5) - Ashland Oil Co.

Mixture Composition:
40% No. 9 Limestone
40% Silica Sand
20% Limestone Sand
6.0% Asphalt Cement (PAC-5)

Comments: Dust returned to the fines bin. Project was done under a change order. Plant was operated automatic.

Project No: Fulton County, SP GROUP 57 (1962)

Roads: SP 38-47,Fulton-Clinton (US 51) Road from the Fulton By-Pass near the N.W.C.L. of Fulton to the Hickman Co. Line - 5.900 miles.

SP 38-467,The US 51-Tennessee State Line (US 51 By-Pass in Fulton) Road from Tennessee Line to US 51 near N.W.C.L. of Fulton - 0.832 miles.

Tonnage: 7,475

Unit Bid: $6.89

Contractor: Columbus Asphalt Co., Ken-Tenn const. Co. Columbus, Kentucky

Plant Location: Columbus, Ky.

Plant Description: Simplicity (5000 lbs.)

Bins: Coarse - 35%,Intermed. - 15%,Fine - 45%,Min. Filler-5%

Date Sampled: Aggregates - July 29, 1963
PAC-5 and Mix-August 14, 1963

Materials Source: No. 9 Gravel - Hickman Sand and Gravel
Natural Sand - Hickman Sand and Gravel
Mineral Filler - Fredonia Valley
Asphalt Cement (PAC-5) - Ky. Asphalt Sales

Mixture Composition:
50% No. 9 River Gravel
45% Natural Sand
5% Mineral Filler
5.8% Asphalt Cement (PAC-5)

Comments: The gravel was crushed just prior to loading it into the cold-feed mechanism. The work consisted of re-surfacing P.C. concrete. The pavement was patched and a binder course was laid. A tack coat was used on the binder just prior to surfacing.

Project No: Kenton County, SP GROUP 22(1963)

Roads: SP 59-465, The Cox Road from KY 16 to the Fowler's Creek Road, a distance of 0.700 mile.

SP 59-575, The Beechwood Road from the Bromley-Crescent Springs Pike to the Ashton Road, a distance of 0.950 miles.

SP 59-75, The Covington-Morning View (KY 177) Road from Jct. of Southern and Winston Avenues in Covington to S.C.L. of Covington, a distance of 1.020 miles.

SP 59-335, The Turkeyfoot (KY 1303) Rd. from US 25 to the Richardson Rd. a distance of 4.909 miles.

SP 59-395, Kyles Lane from South End of Overhead over I-75 to KY 17, a distance of 1.250 miles.

Tonnage: 3,385

Unit Bid: $8.38

Contractor: Eaton Asphalt Paving Company

Plant Location: Belleview, KY. at the Standard Materials Gravel Pit.

Plant Description: Hetherington-Berner Batch (5000 lb)

Date Sampled: September 9, 1963

Source of Materials: No. 9 Gravel - Standard Materials
Natural Sand - Standard Materials
Limestone Sand - Standard Materials
Hanover, Ind.
Asphalt Cement (PAC-5) - American Bitumuls and Asphalt Company

Mixture Composition:
40% No. 9 Gravel
40% Natural Sand
20% Limestone Sand
5.6% Asphalt Cement (PAC-5)

Comments: Dust returned to the hot-elevator. No problems were apparent in the paving operation.

Project No: Greenup County, SP GROUP 14 (1963)

Roads: SP 45-211, US 23 from W.C.L. of Greenup extending West - 7.926 miles.

SP 45-31 US 23 from W.C.L. to E.C.L. of Raceland- 0.524 miles.

SP 45-31 US 23 from E.C.L. of Raceland extending East - 1.062 miles.

Tonnage: 10,200

Unit Bid: $9.20

Contractor: Ashland Asphalt Paving Co.

Plant Location: Ashland, Kentucky

Plant Description: Barber-Greene (4000 lbs.)

Date Sampled: August 8, 1963

Materials Source:
No. 9 Slag - Standard Slag
Natural Sand - Jerry's Sand ang Gravel
Slag Sand - Standard Slag
Asphalt Cement (PAC-5) - Ashland Oil & Refining Company

Mixture Composition:

40%	No. 9 Slag
40%	Natural Sand
20%	Slag Sand
7.2%	Asphalt Cement (PAC-5)

Comments: Dust was returned to the hot-elevator. Very little dust was returned to the mixture.

Project No: Hart - Larue County I 65-3(10) 70, SP 50-B40, SP 62-661

Road: The Louisville -Tennessee State Line Road from north end of Bonnieville Interchange to north end of Ky. 224 Interchange - 5.435 miles.

Tonnage: 14, 595

Unit Bid: $5.77

Contractor: Middle West Roads Co. (Paving Contractor)
Elizabethtown Paving (Plant)

Plant Location: Ky. Stone Company, Upton, Ky.

Plant Description: Barber - Greene (130 ton/hr.)

Date Sampled: October 26, 1964

Materials Source: No. 9 Limestone - Ky. Stone Co., Upton, Ky.
Limestone Sand - Ky. Stone Co., Upton, Ky.
Natural Sand - Louisville Sand & Gravel
Asphalt Cement (PAC-5) - American Bitumuls

Mixture Composition:

40%	No. 9 Limestone
20%	Limestone Sand
40%	Natural Sand
5.6%	Asphalt Cement (PAC-5)

Comments: The natural sand was a blend of pit and Ohio River sand. The collected dust was returned to the bottom of the hot-elevator. Plant screens; 9/16-inch, 1/4-inch, No. 6.
Proportions; Coarse - 35% , Intermediate - 15%, Fine-50%.

Project No: Jefferson County, SP GROUP 6 (1964)

Roads: Sections of Fisherville-Finchville Road and Bardstown Road in Jefferson County - 2.100 miles.

Tonnage: 2,410

Unit Bid: $8.60/ton

Contractor: The Murray Company

Plant Location: Avoca, Kentucky

Plant Description: Cummer (5000 lbs.)

Date Sampled: July 22, 1964

Materials Source:
No. 9 Limestone - Jefferson Co. Stone Co.
Limestone Sand - Jefferson Co. Stone Co.
Natural Sand - Nugent Sand Co.
Asphalt Cement (PAC-5) - Sinclair Oil Co.

Mixture Composition: (Calculated from stockpile gradings)

30% No. 9 Limestone
28% Limestone Sand
42% Natural Sand
5.7% Asphalt Cement (PAC-5)

Comments: Natural Sand was a blend of pit sand and Ohio River sand. Collected dust returned to the bottom of the hot-elevator.
Screens; 9/16-in., 1/4-in., 1/8-in.
Proportions; 33% Coarse, 15% Intermediate, 52% Fine

Project No: Oldham County, SP 93-196

Road: The Louisville - Cincinnati (US-42) Road from 4225' west of Goshen to the Henry County Line - 3.000 miles.

Tonnage: 2,550

Unit Bid: $8.50

Contractor: Charles R. Allen

Plant Location: Prospect, Ky.

Plant Description: Hetherington - Berner (2500 lb.)

Date Sampled: August 11, 1964

Materials Source:
No. 9 Limestone - Ohio River Stone
Limestone Sand - Ohio River Stone
River Sand - Nugent Sand & Gravel
Pit Sand - Ballard
Asphalt Cement (PAC-5) - American Bitumuls

Mixture Composition:
40% No.9 Limestone
18% Limestone Sand
42% Sand Blend, 80% River Sand
20% Pit Sand
5.4% Asphalt Cement (PAC-5)

Comments: Collected dust returned to the bottom of the hot-elevator.
Plant Screens; 9/16-in., 1/4-in., 1/8-in.
Proportions; 33% Coarse, 15% Intermediate, 52% Fine.
The mat appeared very dense immediately after paving.

Project No: Bourbon County, SP GROUP 8(1964)

Roads: Resurfacing projects in Bourbon County - 7.869 miles.

Tonnage: 9,370

Unit Bid: $8.55

Contractor: Hinkle Contracting Corporation, Paris, Ky.

Plant Location: Bourbon County Stone Company, Paris, Ky.

Plant Description: Cummer (4000 lb.)

*Date Sampled: July 17, 1964 & July 23, 1964

Materials Source: No. 9 Limestone - Bourbon County Stone Co.
Natural Sand - Standard Materials
Limestone Sand - Bourbon County Stone Co.
Asphalt Cement (PAC-5) - Kentucky Asphalt Sales

Mixture Composition:

40%	No. 9 Limestone
40%	Natural Sand
20%	Limestone Sand
5.4%	Asphalt Cement (PAC-5)

Comments: Plant Screens; 9/16-in., 1/4-in., 1/8-in.
Proportions; 33% Coarse, 15% Imtermediate, 52% Fine
*Note; This project was sampled twice. On July 17, the bottom of the hot-elevator was clogged as the samples were taken and the mix was cold and non-uniform. The mixture was sampled a second time on July 23. Laboratory data on samples taken July 17, are designated as Sample 1 and data on samples taken July 23, are designated as Sample 2.

Project No: Fayette - Jessamine County, SP 57-8-6, SP 34-114

Road: The Lexington - Nicholasville (US 27) Road from 362' south of Dennis Drive to beginning of widened section north of N.C.L. of Nicholasville (excluding 1.0 mile near R.E.A. office in Jessamine County) - 7.101 miles.

Tonnage: 8,190

Unit Bid: $5.85

Contractor: Lehman-Meade Company, Inc., Lexington, Ky.

Plant Location: Old Frankfort Pike, Lexington, Ky.

Plant Description: Standard Steel (4000 lb.)

Date Sampled: August 14, 1964

Materials Source: No. 9 Limestone - Central Rock Company
Limestone Sand - Allen Co.
River Sand - Standard Materials, Carrollton, Ky.
Asphalt Cement (PAC-5) - Sinclair Refining Co.

Mixture Composition:
53% No. 9 Limestone
30% River Sand
17% Limestone Sand
5.3% Asphalt Cement (PAC-5)

Comments: Samples lettered B and C were taken when the plant was running fully automatic. Sample A was taken when the plant was under manual control. Collected dust was returned to the bottom of the hot-elevator. The mix appeared rich in small areas on the roadway. Plant Screens; 9/16-in., 1/4-in., 1/8-in. Proportions; 35% Coarse, 15% Intermediate, 50% Fine.

Project No: Madison County, I 75-3(4)87

Road: The Covington - Lexington - Tennessee State Line Road from south-end of Barnes Mill Road Interchange to south-end of US 25 Interchange northwest of Richmond - 2.613 miles.

Tonnage: 10,100

Unit Bid: $7.90

Contractor: The Allen Company, Inc., Winchester, Ky.

Plant Location: Boonesboro, Ky.

Plant Description: Standard Steel (5000 lb.)

Date Sampled: September 2, 1964

Materials Source:
No. 9 Limestone - The Allen Co., Inc.
Limestone Sand - The Allen Co., Inc.
Natural Sand - Nugent Sand, Louisville, Ky.
Asphalt Cement (PAC-5) - Ashland Oil & Refining Co.

Mixture Composition:

40%	No. 9 Limestone
20%	Limestone Sand
40%	Natural Sand
5.3%	Asphalt Cement (PAC-5)

Comments: Collected dust was returned to the bottom of the hot-elevator.
Plant Screens; 9/16-in., 1/4-in., 1/8-in.
Proportions; 35% Coarse, 15% Intermediate, 50% Fine.

Project No: Boyle County F220(11), SP 11-220

Road: The Perryville - Danville Road from US 68 in Perryville to KY 34 in Danville - 8.760 miles.

Tonnage: 12,070

Unit Bid: $6.70

Contractor: Danville Construction Co.

Plant Location: Caldwell Stone Company, Danville, Ky.

Plant Description: Hetherington -Berner (5000 lb.)

Date Sampled: September 11, 1964

Materials Source: No. 9 Limestone - Caldwell Stone Co.
Limestone Sand - Caldwell Stone Co.
Natural Sand - Louisville Sand and Gravel
Asphalt Cement (PAC-5) - Ashland Oil & Refining Co.

Mixture Composition:

40%	No. 9 Limestone
20%	Limestone Sand
40%	Natural Sand
5.3%	Asphalt Cement (PAC-5)

Comments: Collected dust returned to the bottom of the hot-elevator.
A Marshall design was performed indicating 5.3% optimum asphalt.
Proportions; 30% Coarse, 17% Intermediate, 53% Fine
Plant Screens; 9/16-in., 1/4-in., 1/8-in.

Project No: Boyd County, I 64-8(10)183, SP 10-115

Road: The Lexington - Catlettsburg Road from west-end of US 60 Interchange near Carter County Line to KY 180 - 3.955 miles.

Tonnage: 10,950

Unit Bid: $6.16

Contractor: Kentucky Road Oiling Co.

Plant Location: Acme Stone Co., Olive Hill, Ky.

Plant Description: Cedarapids (5000 lb.)

Date Sampled: September 17, 1964

Materials Source: No. 9 Limestone - Acme Stone Co.
Limestone Sand - Acme Stone Co.
Collected Limestone Dust - Acme Stone Co.
Natural Sand - Jerries Sand & Gravel
Asphalt Cement (PAC-5) - Ashland Oil & Refining Co.

Mixture Composition:

40%	No. 9 Limestone
15%	Limestone Sand
5%	Collected Limestone Dust
40%	Natural Sand
5.4%	Asphalt Cement (PAC-5)

Comments: Dust was returned to a large dust silo. Some trouble was experienced with the plant scales. Proportions; 18% Coarse, 29% Intermediate, 42% Fine, 11% Dust.

Project No: Bath County, SP 6-124-452, SP 6-64

Road: The Mt. Sterling - Owingsville-Morehead (US - 60) Road from the Montgomery County Line to E.C.L. of Owingsville - 7.580 miles.

Tonnage: 9,140

Unit Bid: $8.80

Contractor: Walker Construction Company, Frenchburg, Ky.

Plant Location: Indian Creek; Frenchburg, Ky.

Plant Description: Cedarapids (5000 lb.)

Date Sampled: September 23, 1964

Materials Source: No. 9 Limestone - A.W. Walker
Crushed Sandstone - A.W. Walker
Natural Sand - Miami Sand
Mineral Filler - Paris, Ky.
Asphalt Cement - (PAC-5) - Ashland Oil & Refining Co.

Mixture Composition:

37%	No. 9 Limestone
20%	Limestone Sand
24%	Natural Sand
16%	Crushed Sandstone
3%	Mineral Filler
5.4%	Asphalt Cement (PAC-5)

Comments: Sandstone appeared to be weathered material which would crush easily. Collected dust was returned at the bottom of the hot-elevator. Sands were fed through individual cold-feed bins. The mix had a fine texture and pleasing appearance.
Plant Screens; 9/16-in., 1/4-in., 1/8-in.
Proportions; 30% Coarse, 18% Intermediate, 49% Fine, 3% Filler.

Project No: Jefferson County, RS 56-298-3
Southside Drive (OLD)

Road: Third Street Road, Ky. 907, from US 31W to the National Turnpike - 7.400 miles.

Tonnage: 8,500

Unit Bid: $5.95

Contractor: Middle West Roads Company

Plant Location: Eiler Avenue
Louisville, Kentucky

Plant Description: Warren Bros. (4000 lbs.)

Date Samples: August 24, 1964

Materials Source:
No. 9 Gravel - Middle West Roads Co.
River Sand - Middle West Roads Co.
Pit Sand - R & W Sand Co.
Asphalt Cement (PAC-5)-Ashland Oil & Refining Co.

Mixture Composition:

50%	No. 9 Gravel
42%	River Sand
8%	Pit Sand
5.4%	Asphalt Cement (PAC-5)

Comments: Mix was laid under heavy traffic conditions and some tack was tracked over the surface.
Plant Screens; 9/16-in., 1/4-in., 1/8-in. or No. 8
Proportions; 25% Coarse, 20% Intermediate, 55% Fine

Project No: Kenton County, SP 59-55-7

Road: The Covington - Nicholson - Walton (KY-16) Road from approximately 1.75 miles south of junction with KY-17 extending southerly - 4.200 miles.

Tonnage: 4,495

Unit Bid: $8.32

Contractor: Eaton Asphalt Paving, Covington, Ky.

Plant Location: Belleview, Ky.

Plant Description: Hetherington - Berner (4000 lb.)

Date Sampled: August 3, 1964

Materials Source: No. 9 Gravel - Standard Materials, Burlington, Ky.
Natural Sand - Standard Materials, Burlington, Ky.
Mineral Filler - Ohio Indiana Stone
Asphalt Cement (PAC-5) - American Bitumuls

Mixture Composition:

40%	No. 9 Gravel
56%	Natural Sand
4%	Mineral Filler
6.0%	Asphalt Cement (PAC-5)

Comments: Collected dust was returned to the bottom of the hot-elevator.
Plant Screens; 9/16-in., 1/4-in., 1/8-in.
Proportions; 25% Coarse, 21% Intermediate, 50% Fine.

Project No: Carroll County, RS 21-412-351

Road: The Locust Road from RH 1018 to the Trimble County Line - 2.750 miles.

Tonnage: 2,180

Unit Bid: $8.10

Contractor: Ohio Valley Paving Company; Carrollton, Kentucky

Plant Location: Milton Road, Carrollton, Ky.

Plant Description: Barber-Greene (150 ton/hr.)

Date Sampled: August 26, 1964

Materials Source: No. 9 Gravel - Standard Materials (Milton,Ky.)
River Sand - Standard Materials (Milton,Ky.)
Limestone Sand - Standard Materials(Hanover)
Asphalt Cement (PAC-9) - American Bitumuls

Mixture Composition:

40%	No. 9 Gravel
40%	River Sand
20%	Limestone Sand
6.0%	Asphalt Cement (PAC-9)

Comments: Collected dust was returned to the bottom of the hot-elevator.
Plant Screens; 9/16-in., 1/4-in, 1/8-in.
Proportions; 30% Coarse, 15% Intermediate, 55% Fine

Project No: Boyd County, I 64-8(11) 187, SP 10-115

Road: The Lexington - Catlettsburg Road from Ky. 180 to west end of bridge over Big Sandy River at the West Virginia State Line - 5.823 miles.

Tonnage: 15,425

Unit Bid: $6.38

Contractor: Ashland Asphalt & Paving Co., Ashland, Ky.

Plant Location: Plant No. 2, Ashland , Kentucky

Plant Description: Barber-Greene (4000 lb.)

Date Sampled: September 15, 1964

Materials Source:
No. 9 Slag - Standard Slag, Ashland, Ky.
Natural Sand - Jerries Sand and Gravel, Portsmouth, Ohio
Mineral Filler - Plum Run, Peobles, Ohio
Asphalt Cement (PAC-5) - Ashland Oil & Refining Co.

Mixture Composition:

45%	No. 9 Slag
49%	Natural Sand
6%	Mineral Filler
7.1%	Asphalt Cement (PAC-5)

Comments: Collected dust was returned to the bottom of the hot-elevator. The mineral filler fed directly to the weigh-bucket. A Marshall design was performed prior to producing the mixture, indicated optimum 6.7%.
Proportions: 30% Coarse, 23% Intermediate, 41% Fine 6% Mineral Filler.
Plant Screens; 9/16-in., 1/4-in., 1/8-in.

Project No: Larue County, SP 62-1

Road: The Hodgenville-Bardstown Road (US 31-E) from E.C.L. of Hodgenville to south-end of bridge over Rolling Fork River at the Nelson County Line.

Distance: 10.489 miles

Tonnage: 12,315 tons

Unit Bid: $8.25

Contractor: E'town Paving Co.

Plant Location: Off US 62 East of Elizabethtown

Plant Description: Hetherington-Berner (4000 lb. Batch)

Date Sampled: April 27, 1965

Source of Materials: Limestone-Waters Const. Co.
Natural Sand - Lucas Sand Co.
Asphalt Cement (PAC-5)-American Bitumuls

Mixture Composition:
42% No. 9 Limestone
34% Natural Sand
24% Limestone Sand
5.7% Asphalt Cement (PAC-5)

Comments: Air Temperature at time sampling 47°F. Mix temperature 280°F. -290°F. when leaving plant.
No problems were apparent in laying the mixture.
Dust returned to the hot-elevator.
Proportions; 29% Coarse, 14% Intermediate, 57% Fine
Plant Screens" 9/16-in., 1/4-in., No.6

Project No: Breckenridge County, SP 14-13

Road: The Louisville-Paducah (US 60) Road from Ky. 448 near S.C.L. of Irvington to E.C.L. of Hardinsburg

Distance: 15.397 miles

Tonnage: 14,790

Unit Bid: $7.70

Contractor: Mago Construction Co. and Charles R. Allen Co.

Plant Location: Hardinsburg (Charles R. Allen Co.)

Plant Description: Barber-Greene Continous (60 tons per/hr.)

Date Sampled: May 3, 1965

Source of Materials: Limestone - White Stone Co, Hardinsburg, Ky.
Blended River and Pit Sand - Cloverport Sand and Gravel
Asphalt Cement (PAC-5) - American Bitumuls, Louisville, Ky.

Mixture Composition:

38%	No. 9 Limestone
40%	Blended River and Pit Sand
22%	Limestone Sand
6.0%	Asphalt Cement (PAC-5)

Comment: Some clay balls in natural sand fine aggregate. Tack application ahead of paver was heavy. Design asphalt content started at 5.6% for a short section on east end of the project . Changed to 6.0% in the afternoon of April 30th.

Project No: Bath-Rowan Counties, SP GROUP 5 (1965)

Roads: SP 6-64, Bath County, The Owingsville-Morehead (US 60) Road, from E.C.L. of Owingsville to west-end of Slate Creek Bridge; distance, 1.819 miles.

SP 6-64, Bath County, The Owingsville-Morehead (US 60) Road from W.C.L. to E.C.L. of Salt Lick; distance, 0.806 miles.

SP 103-82, Rowan County, The Morehead-Owingsville (US 60) Road from KY 32 in Morehead to S.W.C.L. of Morehead; distance, 0.463 miles.

SP 103-2, Rowan County, The Morehead-Olive Hill-Grayson (US 60) Road from E.C.L. of Morehead to the Carter County Line; distance, 8.654 miles.

Distance: 12.036 miles

Tonnage: 15, 025

Unit Bid: $8.40

Contractor: East Kentucky Paving Corporation, Olive Hill, Ky. SP 103-82 and SP 103- 2(this plant sampled), sub-contracted SP 6-64 to A.W. Walker, Frenchburg, Ky.

Plant Location: East of Olive Hill on US 60.

Plant Description: Cedarapids

Date Sampled: May 4, 1965

Source of Materials: Limestone - Acme Stone Co.
Natural Sand - Jerries Sand & Gravel Co.
Asphalt Cement (PAC-5)-Ashland Oil & Refining Co.

Mixture Composition:

44%	No.9 Limestone
29%	Natural Sand
22%	Limestone Sand
5%	Collected Dust
5.4%	Asphalt Cement (PAC-5)

Comment: None

Project No: Pendleton County, SP GROUP 9(1965)

Road: SP 96-237, Pendleton County, The Falmouth-Alexandria (US 27) Road from old US 27 near Bethel Church to northend of Licking River Bridge east of Butler; distance, 5.179 miles.

SP 96-17, Pendleton County, The Falmouth-Alexandria (US 27) Road from approximately 1.1 miles north of southend of Licking River Bridge at Falmouth to old US 27 near Bethel Church; distance, 2.661 miles.

Distance: 7.840 miles

Tonnage: 8,765

Unit Bid: $8.50

Contractor: Mago Construction Company
Butler, Kentucky

Plant Location: Butler, Kentucky

Plant Description: Standard Steel (5000 lb.)

Source of Materials: Limestone-Geoghagan & Mathis
Natural Sand - Standard Materials
Asphalt Cement (PAC-5)- American Bitumuls

Mixture Composition:

34%	No. 9 Limestone
40%	Natural Sand
26%	Limestone Sand
5.8%	Asphalt Cement (PAC-5)

Comments: Surface course laid over newly constructed 2-inch course of binder-mix, with a tack coat over fresh binder. Existing pavement portland concrete. Surface course appears dense.
Plant Screens; 9/16-in., 1/4-in., 1/8-in.
Proportions; 32% Coarse, 18% Intermediate, 50% Fine

Project No: Elliot County, SP-32-49

Road: The Sandy Hook - West Liberty (Ky. 7) Road from northend of bridge over Little Sandy River at Sandy Hook to the Morgan County Line.

Distance: 7.155 miles

Tonnage: 7,810

Unit Bid: $8.60

Contractor: Ky. Road Oiling Company

Plant Location: North of West Liberty on Ky. 7 at Pomp.

Plant Description: Pioneer (Continuous 110 ton/hr.) (Portable Plant)

Date Sampled: May 4, 1965

Source of Materials: Limestone - Licking River Stone Co.
Natural Sand - Jerries Sand & Gravel Co.
Asphalt Cement (PAC-5)-Ashland Oil & Refining Co.

Mixture Composition:

47%	No. 9 Limestone
33%	Natural Sand
20%	Limestone Sand
5.7%	Asphalt Cement (PAC-5)

Comments: Thimble setting 11.2. Mr. L. Logan called 5/7/65, said spray nozzle stopped-up about time sample taken. Also, said fine material being lost thru dust collector. Finer limestone sand being used to compensate.

Project No: Madison County, SP 76-51

Road: The Richmond - Mt. Vernon (US 25 & US 421) Road from Louisville & Nashville Railroad Crossing south of Madison County Courthouse in Richmond to 0.15 mile north of junction of US 25 and US 421 near Terrill (excluding 2, 050 feet of new construction near SE.C.L. of Richmond).

Distance: 4.085 miles

Tonnage: 5,410

Unit Bid: $7.95

Contractor: The Allen Company, Inc.

Plant Location: Boonesboro, Kentucky

Plant Description: Standard Steel

Date Sampled: May 12, 1965

Source of Materials: Limestone - The Allen Company, Inc.
Natural Sand - Louisville Sand & Gravel
Asphalt Cement (PAC-5)-Ashland Oil & Refining Co.

Mixture Composition:

42%	No. 9 Limestone
34%	Natural Sand
24%	Limestone Sand
5.3%	Asphalt Cement (PAC-5)

Comments: Heavy tracking of tack over newly laid surface. Tack coat was covered with natural sand which was whipped-off by the heavy traffic.

Project No: Woodford County, SP GROUP 10(1965)

Roads: SP 120-15, Woodford County, The Versailles-Frankfort (US 60 & US 62) road (North Main Street), from south side of Lexington Street to beginning of concrete pavement near Southern Railroad Tracks; distance 0.313 miles.

SP 120-95, Woodford County, The Versailles-Lexington (US 60) Road (Lexington Street), from east side of Main Street to the Versailles By-Pass; distance 0.902 miles.

SP 120-135, Woodford County, The Versailles-Lawrenceburg (US 62) Road from south side of Lexington Street Via Main Street and Rose Hill Avenue to new W.C.L. of Versailles; distance, 1.510 miles.

Total Group Distance: 2.725 miles

Tonnage: 4,460

Unit Bid: $8.35

Contractor: Robert L. Carter Company

Plant Location: Owenton Road, Frankfort, Ky.

Plant Description: Barber-Greene (9000 lb. batch)

Date Sampled: May 12, 1965

Source of Materials: Limestone - Franklin County Stone Co.
Natural Sand - D.W. & G., Frankfort, Ky.
Asphalt Cement (PAC-5) - Sinclair Oil Co.

Mixture Composition:

46%	No. 9 Limestone
40%	Natural Sand
14%	Limestone Sand
5.7%	Asphalt Cement (PAC-5)

Comments: The mixture appeared to lay exceptionally well. The tack coat was covered with natural sand. Collected dust was wasted.
Proportions; 32%-Coarse, 18%-Intermediate, 50%-Fine.

Project No: Russell County, SP GROUP 4(1965)

Roads: SP 104-78, Russell County, The Jamestown - Albany (US 127) Road from Ky. 55 south of Sewellton to Ky. 1370; distance, 2.300 miles.

SP 104-538, Russell County, The Jamestown - Wolf Creek Dam-Albany (US 127) Road from Ky. 1370 to New Park Entrance; distance, 0.250 miles.

Total Group Distance: 2.550 miles

Tonnage: 2,687

Unit Bid: $9.00

Contractor: R.E. Gaddie

Plant Location: Columbia, Kentucky

Plant Description: Hetherington-Berner(3750 lb. batch)

Date Sampled: June 2, 1965

Source of Materials: Limestone-Shamrock Stone Co.
Natural Sand - Louisville Sand & Gravel
Asphalt Cement (PAC-5) - Ky. Asphalt Sales

Mixture Composition:

48%	No. 9 Limestone
30%	Natural Sand
22%	Limestone Sand
5.7%	Asphalt Cement (PAC-5)

Comments: Tack application appeared satisfactory.
Plant Screens; 9/16-in., 1/4-in., No. 6.
Proportions; 30% Coarse, 15% Intermediate, 55% Fine

Project No: Barren & Metcalfe Counties, SP GROUP 1 (1965)

Roads: SP 5-52, Barren County, The Glasgow-Edmonton (US 68 & KY 80) Road from 261 feet north of new N.E.C.L. of Glasgow extending easterly a distance of 2.697 miles; distance 2.697 miles.

SP 5-52, Barren County, The Glasgow-Edmonton (US 68 & KY 80) Road from 1.779 miles West of the Metcalfe County Line, to the Metcalfe County Line, distance 1.779 miles.

SP 85-84, Metcalfe County, The Edmonton-Glasgow (US 68 & KY 80) Road from 3.264 west of W.C.L. of Edmonton to the Barren County Line; distance, 4.389 miles.

Total Group Distance: 8.865 miles

Tonnage: 7,463

Unit Bid: $8.50

Contractor: Elizabethtown Paving Co.

Plant Location: Pace Quarry, Glasgow, Ky.

Plant Description: Hetherington-Berner (5000 lb. batch)

Date Sampled: June 2, 1965

Source of Materials: Limestone - Pace Quarry, Glasgow, Ky.
Natural Sand - Louisville Sand & Gravel
Asphalt Cement (PAC-5)-American Bitumuls & Asphalt Co.

Mixture Composition:

46%	No. 9 Limestone
28%	Natural Sand
26%	Limestone Sand
5.6%	Asphalt Cement (PAC-5)

Comments: Mix was being laid cold resulting in trouble with the mix pulling. Tack application appeared uniform. Proportions; 35% Coarse, 15% Intermediate, 50% Fine.

Project No: Fayette County, SP GROUP 3 (1965)

Roads: SP 34-304, Fayette County, The Lexington Circle Road from US 25 to Liberty Road; distance, 1.176 miles.

SP 34-4, Fayette County, West Main Street in Lexington from west side of Jefferson Street to east side of Broadway; distance, 0.278 miles.

SP 34-4, Fayette County, The Lexington-Georgetown (Georgetown Street) Road from 100 feet south of Keller Court to North curb of Linberg Street; distance 0.312 miles.

SP 34-104, Fayette County, The Lexington - Richmond Road (East Main Street in Lexington) from eastside of Deweese Street to 150 feet east of east side of Chinoe Road; distance, 1.736 miles.

SP 34-124, Fayette County, The Lexington-Nicholasville Road (South Limestone Street in Lexington) from 100 feet south of Prall Street to south side of Maxwell Street; distance, 0.530 miles.

SP 34-414, Fayette County, West High Street in Lexington from West side of Limestone to Jefferson Street; distance 0.497 miles.

Total Group Distance: 4.529 miles

Tonnage: 9,440

Unit Bid: $7.95

Contractor: Carey Adams, Incorporated

Plant Location: Old Frankfort Pike, Lexington, Kentucky

Plant Description: Standard Steel (4000 lb. batch)

Date Sampled: June 4, 1965

Source of Materials: Limestone - Central Rock Company
Natural Sand - Carrollton Sand & Gravel Co.
Asphalt Cement (PAC-5)-Sinclair Oil.

Mixture composition:

42%	No. 9 Limestone
38%	Natural Sand
20%	Limestone Sand
5.3%	Asphalt Cement (PAC-5)

Comments: Tack application appeared heavy and traffic was tracking tack over the surface in some areas. Some pulling of the surface by the paver screed.

Project No: Henderson County, RS GROUP 50(1965)

Roads: RS 51-199, Henderson County, The Corydon-Dixie-Poole Road from US 60 in Corydon to the SE.C.L. of Corydon; distance, 0.400 miles.

RS 51-199, Henderson County, The Corydon-Dixie-Poole Road from SE.C.L. of Corydon to the Webster County Line; distance, 7.750 miles.

RS 51-379, Henderson County, The Smith Mills -Morganfield Road from Ky. 136 at Smith Mills to the Union County Line; distance 3.937 miles.

RS 117-469, Webster County, The Poole-Dixie-Corydon Road from US 41-A at Poole to the Henderson County Line; distance 0.300 miles.

Total Group Distance: 12.387 miles

Tonnage: 13,055

Unit Bid: $5.40

Contractor: Dixie Pavers, Incorporated

Plant Location: Henderson, Kentucky

Plant Description: Hetherington-Berner

Source of Materials: Limestone - Hopkinsville Stone Co.
Natural Sand - Henderson Materials
Asphalt Cement (PAC-7)-Lion Oil Company

Mixture Composition:

41%	No. 9 Limestone
39%	Natural Sand
16%	Limestone Sand
4%	Limestone Filler
5.5%	Asphalt Cement (PAC-7)

Comments: Plant inspectors extractions indicated the asphalt content was tending to run high.
Plant Screens; 9/16-in., 1/4-in., 1/8-in.
Proportions; 30%-Coarse, 20%-Intermediate, 45%-Fine 5%-Filler.

Project No: Breathitt County, F 102(30), SP 13-257

Road: The Campton - Hazard Road from Old Ky. 15 northeast of Jackson extending southeasterly to Ky. 30 near Quicksand.

Distance: 2.062 miles

Tonnage: 3,965

Unit Bid: $8.15

Contractor: Allen Construction Company

Plant Location: Ky. 15 west of Jackson, Ky.

Plant Description: Barber-Greene Continuous (Portable)

Date Sampled: August 20, 1965

Source of Materials: No. 9 Limestone - Ky. Stone Co.
Natural Sand - Louisville Sand & Gravel
Asphalt Cement (PAC-5)-Ashland Oil

Mixture composition:

46%	No. 9 Limestone
34%	Natural Sand
20%	Limestone Sand
5.7%	Asphalt Cement (PAC-5)

Comments: Paving; Surface shows signs of pulling, extreme in some places. Closes up fairly well after rolling. Compaction; 3 wheel steel used for breakdown, rubber-tired roller for intermediate, two wheel steel tamdem for finish. Plant; Large amount of fines blown from plant, dryer operated at full draft, dust prevalent over entire area of plant.

Project No: Muhlenberg County, SP GROUP 8 (1965)

Roads: SP 89-3, Muhlenberg County; The Greenville-Central City-Beaver Dam (Old US 62 & Ky. 70) Road in Central City from Front Street to 2nd Street, a distance of 0.328 miles.

SP 89-223, Muhlenberg County; The Central City-Madisonville (Ky. 70) Road in Central City from Old US 62 at Reservoir Ave. to W.C.L. of Central City, a distance of 0.488 miles.

SP 89-403, Muhlenberg County; Reservoir Avenue in Central City (US 431 Truck Route), from north curbline of old US 62 to south curbline on 2nd Street, a distance of 0.336 miles.

Total Group Distance: 1.152 miles

Tonnage: 2,330

Unit Bid: $6.50

Contractor: Kapco; Russellville, Kentucky

Plant Location: Russellville, Kentucky

Plant Description: Cedarapids (5000 lb. batch)

Date Sampled: September 29, 1965

Source of Materials: No. 9 Limestone-Kemp Stone Co.
Limestone Sand - Kemp Stone Co.
Natural Sand -Daviess County Sand & Gravel
Asphalt Cement (PAC-5)-Southern States Asphalt

Composition of Mixture:

42%	No. 9 Limestone
38%	Natural Sand
16%	Limestone Sand
4%	Limestone Sand Filler
5.4%	Asphalt Cement (PAC-5)

Comments: Dust separated from limestone at night. Tack coat RS-1 with natural sand cover.
Proportions; 30%-Coarse, 18%-Intermediate, 44%-Fine, 8%-Lime. Dust.

Project No: Jefferson County, SP GROUP 6 (1965)

Roads: SP 56-118, Jefferson County; The Louisville-Bardstown (US 150) Road from east curb line of Clay Street on Broadway in Louisville to south curbline of Taylorsville Road, a distance of 3.577 miles.

SP 56-178, Jefferson County; The Louisville-Elizabethtown (US 31-W) road (22nd Street) from south curbline of Northwestern Parkway to north curbline of Broadway, a distance of 1.484 miles.

Total Group Distance: 5.061 miles

Tonnage: 20,016

Unit Bid: $6.38

Contractor: Middle West Roads

Plant Locatoin: Eiler Avenue
Louisville, Kentucky

Plant Description: Warren Bros. (4000 lb. batch)

Date Sampled: May 7, 1965

Source of Materials: No. 9 Gravel - Middle West Roads
Gravel Sand - Middle West Roads
Natural Sand - Middle West Roads
Asphalt Cement (PAC-5)-Sinclair Refining

Mixture Composition:

37%	No. 9 Gravel
38%	Natural Sand
25%	Gravel Sand
5.2%	Asphalt Cement (PAC-5)

Comments: Tack fairly heavy. Resurfacing an original bituminous pavement.
Plant Screens; 9/16., 1/4-in., 1/8-in.
Proportions; 17%-Coarse, 23%-Intermediate, 60%-Fine.

Project No: Grant County, RS GROUP 34(1965)

Roads: RS 41-194, Grant County, The Critenden-Flingsville Road from US 25 to the Pendleton County Line; distance, 4.413 miles.

RS 41-294, Grant County, The Dry Ridge-Pendleton County Line Road from US 25 in Dry Ridge to E.C.L. of Dry Ridge; distance 0.154 miles.

RS 41-264, Grant County, The Mt. Carmel Road from Ky. 467 extending southeasterly a distance of 1.100 miles; distance 1.100 miles.

RS 41-294, Grant County, The Dry Ridge-Pendleton County Line Road from E.C.L. of Dry Ridge to the Pendleton County Line; distance 4.352 miles.

RS 41-974, Grant County, The Keefer Road from the Owen County Line Extending southeasterly, a distance of 1.800 miles; distance 1.800 miles.

Total Group Distance: 11.810 miles

Tonnage: 11,755

Unit Bid: $8.30

Contractor: Eaton Asphalt Paving Company

Plant Location: Belleview, Kentucky

Plant Description: Hetherington-Berner (5000 lb. batch)

Date Sampled: May 21, 1965

Source of Materials: No. 9 Gravel - Standard Materials
Natural Sand - Standard Materials
Fly Ash - C.G. & E. Co., Cincinnati,Ohio.
Asphalt Cement (PAC-7)-American Bitumuls

Mixture Composition:

42%	No. 9 Gravel
54%	Natural Sand
4%	Fly Ash
6.0%	Asphalt Cement (PAC-7)

Comments: Tack very heavy on Ky. 491 east of US 25, no sand cover and mix trucks tracking on new surface. Some pulling behind pavers and roller not removing all of the cracks.
Plant Screens; 9/16-in., 1/4-in., 1/8-in.
Proportions; 30%-Coarse, 15%-Intermediate, 50%-Fine, 5%-Fly-Ash.

Project No: Hickman - Carlisle Counties, SP GROUP 14(1965)

Roads: SP 53-279, Hickman County; The Bussey-Spicer Road from Ky. 58 approximately 0.3 mile west of W.C.L. of Clinton, extending westerly, a distance of 2.000 miles.

SP 53-799, Hickman County; The St. Dennis Road from Ky. 307 at Beulah extending northwesterly to the Carlisle County Line, a distance of 0.650 miles.

SP 20-724, Carlisle County; The Beulah Road from the Hickman County Line extending northerly to Ky. 80 approximately 1 mile east of Milburn a distance of 1.900 miles.

Total Group Distance: 4.550 miles

Tonnage: 2,650

Unit Bid: $7.40

Contractor: Ken-Tenn Construction Co. (Columbus Asphalt Co.)

Plant Location: Columbus, Kentucky

Plant Description: Simplicity (5000 lb.)

Date Sampled: June 16, 1965

Source of Materials: No. 9 Gravel - Hickman Sand & Gravel
Natural Sand - Hickman Sand & Gravel
Mineral Filler - Fredonia, Kentucky
Asphalt Cement (PAC-7) - Ky. Asphalt Sales

Mixture Composition:
32% No. 9 Gravel
48% Natural Sand
16% Gravel Sand
4% Mineral Filler
5.8% Asphalt Cement (PAC-7)

Comments: Mixing Time: 30 Sec. dry, 15 sec. wet. Gravel crushed from stockpile and fed directly to plant.
Temperatures; asphalt-270°F, aggregate- 300°F, Mix - 290°F.
Plant Screens; 9/16-in., 1/4-in., No. 6
Proportions; 35%-Coarse, 15%-Intermediate, 46%-Fine, 4%-Filler.

Project No: Bourbon County SP GROUP 18 (1965)

Roads: SP 9-59, Bourbon County, The Paris-Jacktown Road from US 68 to the Black's Cross Road, a distance of 5.300 miles.

SP 9-959, Bourbon County, The Stringtown Road from the Paris-Jacktown Road to Ky. 537, a distance of 2.600 miles.

Total Group Distance: 7.900 miles

Tonnage: 6,684

Unit Bid: $8.60

Contractor: Hinkle Contracting, Inc.

Plant Location: Quincy Quarry, Paris, Ky.

Plant Description: Cummer (4000 lb. batch)

Date Sampled: September 2, 1965

Source of Materials: No. 9 Limestone-Quincy Quarry
Limestone Sand- Quincy Quarry
Asphalt Cement (PAC-7) - Ky. Asphalt Sales

Mixture Composition: 55% No. 9 Limestone
45% Limestone Sand
5.8% Asphalt Cement (PAC-7)

Comments: This was an all limestone mix used to skin patch the roads before resurfacing.

Job Formula

Coarse	36%	#8	47-55
Intermediate	19%	#50	9-17
Fine	41%	#100	7-11
Dust	4%		

Collected dust fed to silo where it is stored and fed back at a 4% rate.

APPENDIX II

GRADATION TEST RESULTS, EXTRACTED AGGREGATE
Class I-Type B (Modified)

Project Number	Percent Passing Sieve Size 1/2-in.	3/8-in.	No.4	No. 8	No. 16	No. 50	No. 100	No. 200
			(Limestone and Natural Sand)					
SP GROUP 25(1963)	100.0	96.1	72.2	51.8	40.0	10.7	5.2	2.9
SP GROUP 9 (1963)	100.0	94.9	65.6	52.1	41.6	9.0	3.9	2.3
SP GROUP 10(1963)	100.0	95.4	71.8	50.2	39.5	10.3	4.4	3.0
SP GROUP 34(1963)	100.0	96.6	71.1	53.4	43.0	10.7	4.1	1.5
SP 109-48	100.0	95.1	74.9	55.2	42.4	10.2	4.0	2.5
RH GROUP 4(1963) (Avoca)	100.0	94.2	70.4	52.0	39.9	10.0	6.0	4.9
RH GROUP 4(1963) (Fern Creek)	100.0	95.4	71.5	51.6	39.8	9.2	4.6	3.0
RH GROUP 5&6(1963)	100.0	93.0	65.8	48.6	36.8	10.8	7.5	5.5
I-75-4(15)98 SP 34-744	100.0	97.7	72.0	48.8	38.0	11.3	5.6	4.3
SP GROUP 21(1963)	99.5	90.8	67.5	51.4	43.1	10.9	3.1	2.1
SP 91-139	100.0	95.1	69.7	49.4	37.6	11.4	6.3	4.4
SP 7-84	100.0	96.0	69.7	52.2	33.5	6.6	3.7	3.0
SP 118-220-7	100.0	96.0	68.3	48.1	37.4	9.1	2.6	1.4
SP GROUP 15(1963)	100.0	94.1	66.1	48.1	39.1	12.7	6.1	4.3
Average	100.0	95.0	69.7	50.9	39.4	10.2	4.8	3.2
Median	100.0	95.1	70.0	51.5	39.6	10.5	4.5	3.0
SP 60-18	100.0	94.1	71.7	57.0	50.2	12.6	4.2	2.6
			(Gravel, Natural Sand, Mineral Filler)					
SP GROUP 57(1962)	100.0	95.5	73.5	50.0	39.2	8.4	3.4	1.4
			(Gravel, Natural Sand, Limestone Sand)					
SP GROUP 22(1963)	100.0	95.2	64.5	50.7	35.0	12.1	4.7	2.8
			(Slag, Natural Sand, Limestone Sand)					
SP GROUP 14(1963)	100.0	93.5	63.6	43.7	36.8	10.1	3.6	1.9
			(Limestone and Silica Sand)					

EXTRACTION TEST RESULTS, SAMPLED MIXTURES
Class I, Type B (Modified)

Project No.	Sample	Asphalt Content (%) Design	Extraction
SP GROUP 25(1963)	A	5.7	5.6
	B		6.1
	C		6.0
SP GROUP 9(1963)	A	5.7	6.0
	B		5.9
	C		6.0
SP GROUP 10(1963)	A	5.8	5.7
SP GROUP 34(1963)	A	5.5	5.4
	B		5.5
	C		5.6
SP 109-48	A	5.7	5.1
	B		5.5
	C		5.2
RH GROUP 4(1963) (Avoca)	A	5.6	5.6
	B		5.5
	C		5.4
RH GROUP 4(1963) (Fern Creek)	A	5.6	5.5
	B		5.5
	C		5.8
RH GROUP 5&6(1963)	A	5.5	5.6
	B		5.7
	C		5.5
I 75-4(15)98	A	5.8	5.7
	B		5.5
SP GROUP 21(1963)	A	5.6	5.3
	B		5.2
	C		5.5
SP 91-139	A	5.6	5.5
	B		5.9
	C		5.5
SP 7-84	A	5.6	5.1
	B		5.5
	C		5.2
SP 118-220-7	A	5.6	5.3
	B		5.3
	C		5.4
SP GROUP 15(1963)	A	5.6	5.5
	B		5.3
	C		5.4
SP 60-18	A	6.0	5.7
	B		5.5
	C		6.2
SP GROUP 57(1962)	A	5.8	5.7
	B		6.4
	C		5.8
SP GROUP 22(1963)	A	5.6	6.0
	B		5.4
	C		5.6
SP GROUP 14(1963)	A	7.2	7.2
	B		6.7
	C		6.8

MARSHALL TEST RESULTS, SAMPLED MIXTURES, REHEATED
Class I, Type B (Modified)

Project Number	Asphalt Content Project Design (%)	Asphalt Content Extraction (%)	Stability (Lbs.)	Flow (0.01 In.)	Unit Weight (Lbs./Cu.Ft.)	Percent Agg.	Void Mix
			(Limestone and Natural Sand)				
SP GROUP 25(1963)	5.7	5.9	1658	7	145.2	16.2	3.3
SP GROUP 9(1963)	5.7	6.0	1339	7	147.3	15.0	2.2
SP GROUP 10(1963)	5.8	5.7	937	6	145.6	19.9	5.3
SP GROUP 34(1963)	5.5	5.5	1398	6	144.6	15.7	6.8
SP 109-48	5.7	5.3	1815	8	142.2	16.7	7.4
RH GROUP 4(1963) (Avoca)	5.6	5.5	1659	8	148.2	16.4	5.5
RH GROUP 4(1963 (Fern Creek)	5.6	5.6	1265	6	145.6	16.5	6.
RH GROUP 5&6(1963)	5.5	5.6	1843	8	150.4	15.1	2.8
I-75-4(15)98	5.8	5.6	1739	9	151.3	12.6	1.5
SP GROUP 21(1963)	5.6	5.3	817	7	144.0	16.5	5.6
SP 91-139	5.6	5.6	2048	10	150.0	12.8	0.7
SP 7-84	5.6	5.3	1323	6	143.6	16.7	6.8
SP 118-220-7	5.6	5.3	1095	6	142.4	17.8	8.0
SP GROUP 15(1963)	5.6	5.4	1569	7	150.1	12.0	0.4
Average	5.65	5.5	1465	7	146.5	15.4	4.5
Median	5.6	5.5	1484	6	145.6	16.4	5.3
			(Limestone and Silica Sand)				
SP 60-18	6.0	5.8	1127	6	141.5	19.6	7.7
			(Gravel, Natural Sand, Limestone Sand)				
SP GROUP 22(1963)	5.6	5.7	1572	6	147.4	16.0	4.4
			(Slag, Natural Sand, Slag Sand)				
SP GROUP 14(1963)	7.2	6.9	1640	9	141.7	17.3	4.7
			(Gravel, Natural Sand, Mineral Filler)				
SP GROUP 57(1962)	5.8	6.0	1020	7	138.5	16.7	4.2

AGGREGATE GRADATIONS, MARSHALL DESIGNS
(Class I, Type B (Modified)

Project Number	Percent Passing Sieve Size 1/2-in.	3/8-in.	No.4	No. 8	No.16	No. 50	No. 100	No. 200
			(Limestone and Natural Sand)					
SP GROUP 25(1963)	100.0	92.5	70.1	56.8	45.7	11.4	3.6	2.2
SP GROUP 9(1963)	100.0	98.3	78.4	60.4	47.1	10.4	4.3	2.6
SP GROUP 10(1963)	100.0	94.7	66.1	50.1	39.2	8.4	2.8	1.8
SP GROUP 34(1963)	100.0	97.7	70.3	50.7	39.0	13.3	6.6	4.1
SP 109-48	100.0	96.0	80.3	62.3	48.4	13.5	6.0	3.1
RH GROUP 4(1963) (Avoca Plant)	100.0	94.3	67.9	53.6	40.7	8.0	4.2	2.8
RH GROUP 4(1963) (Fern Creek Plant)	100.0	96.6	74.4	55.3	41.8	9.3	4.6	2.4
RH GROUP 5&6(1963)	100.0	96.7	78.9	62.1	44.8	11.5	7.5	5.0
I 75-4(15)98	100.0	94.2	64.8	48.5	39.0	10.4	4.4	3.0
SP GROUP 21(1963)	99.7	89.3	64.5	48.2	39.9	10.3	3.3	2.2
SP 91-139	100.0	94.7	64.7	48.3	36.1	4.9	3.5	2.2
SP 7-84	100.0	96.1	68.5	54.2	36.1	5.3	2.7	1.9
SP 118-220-7	100.0	97.7	71.8	51.7	39.3	9.9	3.5	1.8
SP GROUP 15(1963)	100.0	92.6	78.7	56.5	45.4	12.4	5.6	2.7
			(Limestone and Silica Sand)					
SP 60-18	99.7	90.6	63.4	56.3	49.8	9.6	3.7	1.6
			(Gravel, Natural Sand, Mineral Filler)					
SP GROUP 57(1962)	100.0	95.2	66.6	50.1	38.9	13.8	6.8	3.2
			(Gravel, Natural Sand, Limestone Sand)					
SP GROUP 22(1963)	100.0	96.3	69.7	52.4	40.3	13.6	5.2	3.1
			(Slag, Natural Sand Limestone Sand)					
SP GROUP 14(1963)	100.0	92.9	67.6	54.5	45.6	12.0	3.8	2.1

RESULTS LABORATORY, MARSHALL DESIGNS
Class I, Type B (Modified)

Project Number	Optimum Asphalt Content (%)	Stability (Lbs.)	Flow (0.01 In.)	Unit Weight (Lbs./Cu.Ft.)	Percent Voids Agg.	Mix
		(Limestone and Natural Sand)				
SP GROUP 25(1963)	6.1	750	3	143.6	17.5	4.2
SP GROUP 9(1963)	5.9	940	6	143.4	17.1	4.5
SP GROUP 10(1963)	6.3	790	6	143.9	17.3	5.2
SP GROUP 34(1963)	5.4	2160	7	147.9	14.0	4.7
SP 109-48	5.5	1880	6	145.7	14.7	4.2
RH GROUP 4(1963) (Avoca)	5.9	1600	8	146.8	17.4	5.1
RH GROUP 4(1963) (Fern Creek)	6.0	1425	5	146.2	16.3	4.9
RH GROUP 5&6(1963)	5.8	1820	7	149.2	15.6	3.0
I-75-4(15)98 SP 34-744	5.6	1560	8	148.7	14.1	3.6
SP GROUP 21(1963)	5.6	1070	8	145.2	16.1	4.1
SP 91-139	5.3	2515	7	150.7	12.5	0.7
SP 7-84	6.3	1210	8	143.8	17.3	4.8
SP 118-220-7	6.0	1150	6	144.2	17.3	5.7
SP GROUP 15(1963)	5.8	1290	7	144.9	15.3	2.8
Average	5.8	1445	7	146.0	15.9	4.2
		(Limestone and Silica Sand)				
SP 60-18	7.1	650	7	139.9	21.6	7.0
		(Gravel, Natural Sand, Limestone Sand)				
SP GROUP 22(1963)	5.8	1470	6	147.8	16.2	3.6
		(Slag, Natural Sand, Slag Sand)				
SP GROUP 14(1963)	7.7	1020	6	136.5	21.4	7.0
		(Gravel, Natural Sand, Mineral Filler)				
SP GROUP 57(1962)	6.0	1210	7	40.1	16.0	3.2

GRADATIONS OF STOCKPILE AGGREGATES
Class I, Type B (Modified)

Aggregate Type	Percent Passing Sieve Size 1/2-in.	3/8-in.	No.4	No. 8	No. 16	No. 50	No.100	No. 200
				SP GROUP 25 (1963)				
No.9 Limes	100.0	81.6	18.8	2.4	1.3	0.9	0.9	0.8
Limes. Sand	100.0	100.0	99.9	96.4	67.3	27.7	16.4	8.4
Nat. Sand	100.0	100.0	97.9	90.7	77.5	11.7	0.3	0.1
				SP GROUP 9 (1963				
No. 9 Limes	100.0	93.4	44.8	12.5	5.2	3.0	2.5	1.9
Limes. Sand	100.0	100.0	99.7	94.0	70.4	27.8	14.6	7.4
Nat. Sand	100.0	99.8	96.3	88.0	75.5	7.6	0.6	0.2
				SP GROUP 10 (1963)				
No. 9 Limes	100.0	87.6	21.1	3.2	1.6	1.1	0.9	0.7
Limes. Sand	100.0	100.0	100.0	79.2	51.0	21.2	13.1	8.6
Nat. Sand	100.0	100.0	97.8	86.5	73.0	10.0	0.6	0.3
				SP GROUP 34 (1963)				
No. 9 Limes	100.0	92.3	29.4	8.1	3.9	2.0	1.5	1.1
Limes. Sand	100.0	100.0	98.1	76.6	55.8	26.2	15.3	9.0
Nat. Sand	100.0	100.0	98.1	87.0	76.2	10.6	0.7	0.2
				SP 109-48 (1963)				
No. 9 Limes	100.0	88.1	37.4	12.4	5.3	2.8	2.3	1.8
Limes Sand	100.0	100.0	100.0	95.8	79.4	37.1	19.9	9.3
Nat. Sand	100.0	100.0	96.5	84.7	68.4	7.7	0.5	0.1
				RH GROUP 4(1963)				
No. 9 Limes	100.0	86.8	23.9	4.5	2.8	2.3	2.1	1.3
Limes. Sand	100.0	100.0	99.7	79.0	50.8	23.4	16.8	11.2
Nat. Sand	100.0	100.0	98.1	90.0	70.6	6.2	0.8	0.3
				RH GROUP 4(1963)				
No. 9 Limes	99.6	82.5	24.4	6.1	4.2	3.6	3.3	2.1
Limes. Sand	100.0	100.0	99.7	76.1	48.3	22.3	13.6	7.6
Nat. Sand	100.0	100.0	100.0	89.5	71.0	8.1	0.7	0.2
				RH GROUP 5 & 6 (1963)				
No. 9 Limes	100.0	85.3	27.4	9.9	5.3	3.9	3.6	2.8
Limes.Sand	100.0	99.9	99.5	80.9	49.9	24.3	18.4	12.4
Nat. Sand	100.0	100.0	98.3	88.3	69.7	10.1	4.0	2.1
				I-75 (1963)				
No. 9 Limes	100.0	85.2	15.8	3.1	2.7	2.0	1.7	1.5
Limes. Sand	100.0	100.0	96.9	69.8	45.7	22.0	15.3	11.0
Nat. Sand	100.0	100.0	97.8	80.2	67.4	10.9	1.9	1.0
				SP GROUP 21 (1963)				
No. 9 Limes	99.2	75.9	15.6	1.6	0.9	0.8	0.7	0.6
Limes. Sand	100.0	100.0	99.6	67.7	44.2	20.1	13.8	10.1
Nat. Sand	100.0	99.9	99.7	85.4	76.5	14.7	1.8	0.8
				SP 91-139 (1963)				
No. 9 Limes	100.0	77.3	7.4	1.2	0.6	0.5	0.4	0.4
Limes. Sand	100.0	100.0	99.8	77.0	40.4	17.8	12.4	8.8
Nat. Sand	100.0	100.0	96.8	82.6	72.5	11.6	1.2	0.5
				SP 7-84 (1963)				
No. 9 Limes	99.7	87.4	18.2	1.6	0.8	0.6	0.6	0.5
Limes. Sand	100.0	100.0	99.7	85.8	55.2	19.2	11.3	7.2
River Sand	100.0	100.0	99.8	85.7	52.5	4.0	1.0	0.5
				SP 118-220-7 (1963)				
No. 9 Limes	100.0	91.8	26.7	2.2	1.4	1.0	0.9	0.7
Limes. Sand	100.0	100.0	99.8	86.4	62.3	27.8	15.0	6.8
Nat. Sand	100.0	100.0	97.7	84.6	68.0	9.0	0.3	0.1
				SP GROUP 15 (1963)				
No. 9 Limes	100.0	81.6	51.6	20.0	13.7	7.6	5.2	3.3
Limes. Sand	100.0	100.0	98.6	83.0	60.8	30.8	16.2	6.7
Nat. Sand	100.0	100.0	96.1	79.7	69.5	8.0	0.8	0.2
				SP 60-18 (1963)				
No. 9 Limes	99.6	77.0	9.7	1.1	0.5	0.3	0.3	0.3
Limes. Sand	99.6	99.1	97.8	79.9	51.8	21.7	13.4	6.7
Silica Sand	100.0	100.0	99.8	99.7	98.1	12.9	2.0	0.4
				SP GROUP 57 (1962)				
No. 9 Gravel	100.0	83.5	19.9	4.4	0	0	0	0
Nat. Sand	-	100.0	95.1	87.7	71.3	14.3	1.9	0.7
Min. Filler	-	-	-	-	100.0	99.0	96.0	73.0
				SP GROUP 22 (1963)				
No. 9 Gravel	100.0	90.1	27.7	2.9	0.4	0	0	0
Limes. Sand	100.0	100.0	99.6	82.4	56.9	29.4	21.5	15.4
Nat. Sand	100.0	99.9	98.5	88.2	70.2	17.6	3.1	1.2
				SP GROUP 14 (1963)				
No. 9 Slag	100.0	83.1	22.0	6.3	4.8	2.8	1.5	0.9
Slag Sand	100.0	100.0	99.2	89.8	64.8	26.1	14.2	7.5
Nat. Sand	100.0	100.0	97.2	87.2	78.7	10.8	1.0	0.3

SPECIFIC GRAVITY AND ABSORPTION OF AGGREGATE
Class I Type B (Modified)

Project Number	Specific Gravity Bulk Oven Dry	Specific Gravity Apparent	Specific Gravity Sat. Sur. Dry	Absorption (%) Water	Absorption (%) Bitumen**	Virtual** Specific Gravity
			(Limestone & Natural Sand)			
SP GROUP 25 (1963)	2.61	2.71	2.65	1.4	0.3	2.63
SP GROUP 9(1963)	2.61	2.70	2.64	1.3	0.6	2.65
SP GROUP 10(1963)	2.62	2.69	2.64	1.0	1.0	2.69
SP GROUP 34(1963)	2.60	2.71	2.64	1.7	1.5	2.71
SP 109-48	2.58	2.73	2.64	2.2	1.4	2.67
RH GROUP 4(1963) (Avoco Plant)	2.68	2.81	2.73	1.7	0.8	2.74
RH GROUP 4(1963) (Fern Creek Plant)	2.64	2.79	2.69	2.1	1.2	2.72
RH GROUP 5&6(1963)	2.68	2.81	2.73	1.7	0.6	2.71
I 75-4(15)98	2.62	2.73	2.66	1.6	1.2	2.70
SP GROUP 21(1963)	2.62	2.73	2.66	1.6	0.6	2.66
SP 91-139	2.60	2.71	2.64	1.5	0.6	2.64
SP 7-84	2.62	2.70	2.65	1.2	0.9	2.68
SP 118-220-7	2.63	2.76	2.67	1.9	1.1	2.70
SP GROUP 15(1963)	2.59	2.69	2.63	1.5	0.3	2.61
			(Limestone & Silica Sand)			
SP 60-18	2.65	2.72	2.68	1.0	0.6	2.63
			(Gravel, Natural Sand, Mineral Filler)			
SP GROUP 57(1962)	2.52	2.65	2.57	2.0	0.4	2.54
			(Gravel, Natural Sand, Limestone Sand)			
SP GROUP 22(1963)	2.65	2.78	2.70	1.8	0.9	2.71
			(Slag and Natural Sand)			
SP GROUP 14(1963)	2.55	2.77	2.63	3.0	1.4	2.65

* Specific gravity and water absorption values determined on the blended aggregates.

** Bitumen absorption and measured maximum theoretical specific gravity of paving mixtures (Rice's Method) determined as outlined in "Mix Design Methods for Asphalt Concrete," The Asphalt Institute, February, 1962.

TEST RESULTS ASPHALT CEMENTS

Project No.	Specific Gravity 77/77F.	Penetration, 77°F, 100g. 5 sec.	Ductility at 77° F. cms.	Thin Film Weight Loss (%)	Residue, Thin Film Test	
					Ductility	% Ret. Pen.
SP GROUP 22(1963)	1.03	91.0	150+	0.12	150+	59.6
SP 7-84	1.00	89.8	150+	0.10	150+	59.0
SP GROUP 21(1963)	1.00	89.5	150+	0.02	150+	59.0
RH GROUPS 5&6(1963)	1.01	78.0	150+	0.13	145	61.2
SP GROUP 15(1963)	1.00	89.7	150+	0.04	150+	56.1
SP 91-139	1.00	85.5	150+	0.03	150+	60.0
SP GROUP 24(1963)	1.01	92.0	150+	0.09	150+	61.6
SP 109-48	1.00	80.7	150+	0.17	150+	62.3
SP 118-220-7	1.00	84.2	150+	0.11	150+	60.9
SP GROUP 14(1963)	1.00	87.5	150+	0.11	150+	60.2
SP GROUP 25(1963)	1.01	78.0	150+	0.04	--	65.6
SP GROUP 26(1963)	1.01	78.5	150+	0.08	150+	74.3
SP GROUP 10(1963)	1.00	89.3	150+	0.34	150+	52.6
SP GROUP 9(1963)	1.01	92.7	150+	0.18	150+	55.8
SP GROUP 34(1963)	1.01	89.2	150+	0.03	150+	63.0
SP GROUP 10(1963)	1.02	89.1	150+	0.15	150+	53.9
I 75-4(15)98	1.01	87.3	150+	0.19	150+	45.0
RH GROUP 4(1963),Avoca	1.01	86.7	150+	0.14	150+	50.2
RH GROUP 4(1963) Fern Creek	1.01	91.7	150+	0.11	150+	55.8
SP 60-18	1.01	93.0	150+	0.09	150+	65.3

GRADATION TEST RESULTS, EXTRACTED AGGREGATE
(Type A Mixtures Sampled in 1964)

Project Number	Percent Passing Sieve Size 1/2-in.	3/8-in.	No. 4	No. 8	No. 16	No. 50	No. 100	No. 200
(Limestone and Natural Sand)								
I 65-3(10)70	100.0	98.3	77.3	57.4	45.7	13.4	7.9	4.8
SP GROUP 6(1964)	100.0	90.5	67.2	57.0	42.7	13.7	8.3	4.7
SP 93-196	100.0	94.8	70.4	55.7	42.4	17.8	12.2	8.5
SP GROUP 8(1964) (Sample 1)	100.0	99.1	75.2	55.3	40.7	14.3	8.2	5.8
SP GROUP 8(1964) (Sample 2)	100.0	99.4	79.7	58.7	42.5	14.0	7.5	5.8
SP 57-8-6	100.0	97.8	70.1	51.0	37.5	11.6	5.8	3.7
I 75-3(4)87	100.0	95.7	71.5	54.7	39.5	13.4	8.5	5.4
F 220-11	100.0	97.6	67.9	47.0	37.0	11.2	5.6	3.3
I 64-8(10)183	100.0	94.0	63.6	45.9	35.2	15.9	8.9	5.1
Average	100.0	96.4	71.4	53.6	40.4	13.9	8.1	5.2
Median	100.0	96.6	71.6	53.4	40.1	13.4	7.6	4.8
(Limestone, Crushed Sandstone, Natural Sand, Mineral Filler)								
SP 6-124-452	100.0	96.5	72.4	55.9	43.5	19.9	8.0	5.2
(River Gravel, River Sand, Pit Sand)								
RS 56-298-3	100.0	96.5	66.0	47.9	39.7	15.5	8.9	5.6
(Gravel, Pit Sand, Mineral Filler)								
SP 59-55-7	100.0	96.7	73.5	55.0	41.2	12.4	4.4	2.8
(Gravel, River Sand, Limestone Sand)								
RS 21-412-351	100.0	96.1	67.4	53.4	40.2	15.2	8.3	6.2
(Slag, Natural Sand, Mineral Filler)								
I 64-8(11)187	100.0	93.6	66.0	48.0	41.0	13.2	5.0	3.6

EXTRACTION TEST RESULTS, SAMPLED MIXTURES
(Type A Mixtures Sampled in 1964)

Project Number	Sample	Asphalt Content(%) Design	Extraction
I 65-3(10)70	A	5.6	5.7
	B		6.1
	C		5.4
SP GROUP 6(1964)	A	5.7	5.5
	B		5.7
SP 93-196	A	5.4	5.3
	B		5.2
	C		5.4
SP GROUP 8(1964)	A-1	5.4	5.8
	C-1		5.6
	A-2		5.5
	B-2		5.5
SP 57-8-6	A	5.3	6.5
	B		6.9
	C		5.4
I 75-3(4)87	A	5.3	5.5
	B		5.5
	C		5.1
F 220-11	A	5.3	5.0
	B		5.1
	C		5.3
I 64-8(10)183	A	5.4	6.0
	B		5.9
	C		6.0
SP 6-124-452	A	5.4	6.2
	B		5.7
	C		5.7
RS 56-298-3	A	5.4	5.2
	B		5.7
	C		4.9
SP 59-55-7	A	6.0	6.0
	B		5.8
	C		5.6
RS 21-412-351	A	6.0	6.4
	B		6.2
	C		5.9
I 64-8(11)187	A	7.1	6.3
	B		7.1
	C		6.4

MARSHALL TEST RESULTS, SAMPLED MIXTURES, REHEATED
(Type A Mixtures Sampled in 1964)

Project Number	Asphalt Content Project Design (%)	Asphalt Content Extraction (%)	Stability (Lbs.)	Flow (0.01 In.)	Unit Weight (Lbs./Cu.Ft.)	Percent Agg.	Void Mix
			(Limestone and Natural Sand)				
I 65-3(10)70	5.6	5.7	1730	9.6	144.7	16.5	3.5
SP GROUP 6(1964)	5.7	5.6	1942	7.0	149.1	14.7	4.8
SP 93-196	5.4	5.3	2492	8.0	152.7	12.2	0.3
SP GROUP 8(1964) Sample 1	5.4	5.7	2750	7.0	147.3	14.6	6.2
SP GROUP 8(1964) Sample 2	5.4	5.5	1926	6.6	147.6	14.3	4.9
SP 57-8-6	5.3	6.3	1623	10.0	139.8	20.8	8.1
I 75-3(4)87	5.3	5.3	2392	5.6	148.2	14.9	3.5
F 220-11	5.3	5.1	2578	8.0	147.8	13.2	3.9
I 64-8(10)183	5.4	5.9	2479	13.0	148.9	14.1	2.2
			(Limestone, Crushed Sandstone, Natural Sand, Mineral Filler)				
SP 6-124-452	5.4	5.9	2194	9.7	147.2	14.3	1.3
Average		5.6	2210	8.5	147.3	15.0	3.9
			(Gravel, River Sand, Pit Sand)				
RS 56-298-3	5.4	5.3	1811	7.3	141.9	16.3	8.1
			(Gravel, Pit Sand, Mineral Filler)				
SP 59-55-7	6.0	5.8	1116	6.3	147.8	15.3	3.2
			(Gravel, River Sand, Mineral Filler)				
RS 21-412-351	6.0	6.2	1532	10.0	141.8	18.9	5.6
			(Slag, Natural Sand, Mineral Filler)				
I 64-8(11)187	7.1	6.6	1276	9.7	136.1	17.4	5.8

AGGREGATE GRADATION, MARSHALL DESIGNS
(Type A Projects Sampled in 1964)

Project Number	Percent Passing Sieve Size							
	1/2-in.	3/8-in.	No. 4	No.8	No.16	No. 50	No.100	No.200
(Limestone and Natural Sand)								
I 65-3(10)70	100.0	95.6	68.5	54.8	43.4	12.1	7.3	4.6
SP GROUP 6(1964)	100.0	92.4	70.0	54.4	35.4	13.1	7.7	4.3
SP 93-196	100.0	95.0	67.5	53.1	41.3	16.4	11.3	7.5
SP GROUP 8(1964)	100.0	99.0	73.1	56.8	43.8	12.4	5.4	3.2
SP 57-80-6	100.0	97.5	66.5	46.7	35.8	11.8	6.2	4.8
I 75-3(4)87	100.0	93.4	68.0	52.5	38.2	11.4	7.5	5.7
F 220(11)	100.0	98.0	64.8	48.8	40.4	12.6	7.0	3.8
I 64-8(10)183	100.0	93.0	65.1	52.9	44.4	15.6	7.0	3.6
(Limestone, Crushed Sandstone, Natural Sand, Mineral Filler)								
SP 6-124-452	100.0	96.4	69.4	58.4	48.2	18.8	7.7	4.7
(Gravel, River Sand, Pit Sand)								
RS 56-298-3	100.0	95.9	66.7	45.8	37.7	12.3	5.4	3.0
(Gravel, Pit Sand, Mineral Filler)								
SP 59-55-7	100.0	94.2	69.0	54.3	42.7	13.5	6.3	4.4
(Gravel, River Sand, Limestone Sand)								
RS 21-412-351	100.0	96.4	72.4	56.2	43.0	15.0	6.3	4.3
(Slag, Natural Sand, Mineral Filler)								
I 64-8(11)187	100.0	94.2	61.0	48.1	42.8	15.4	7.5	5.8

LABORATORY RESULTS, MARSHALL DESIGNS
(Type A Projects Sampled in 1964)

Project Number	Optimum Asphalt Content (%)	Stability (Lbs.)	Flow (0.01 in.)	Unit Weight (Lbs./Cu.Ft.)	Percent Voids Agg.	Mix
		(Limestone and Natural Sand)				
I 65-3(10)	5.5	1400	9.0	145.8	15.8	3.0
SP GROUP 6(1964)	6.1	1180	8.0	145.4	16.5	4.0
SP 93-196	5.0	2180	11.0	148.2	14.6	3.3
SP GROUP 8(1964)	6.2	1350	11.0	143.8	17.1	5.8
SP 57-8-6	5.1	1430	9.0	148.6	14.8	4.0
I 75-3(4)87	5.5	1410	7.0	146.7	15.9	4.4
F 220(11)	5.2	1910	5.0	148.5	12.6	3.7
I 64-8(10)183	5.9	1000	9.0	141.7	18.3	6.0
		(Crushed Sandstone, Natural Sand, Mineral Filler)				
SP 6-124-452	5.5	2100	9.0	146.2	14.7	2.5
Average	5.6	1551	9.0	146.1	15.6	4.1
		(Gravel, River Sand, Pit Sand)				
SP 56-298-3	6.2	880	8.0	144.1	16.0	4.9
SP 59-55-7	6.1	980	7.0	148.3	15.2	2.6
		(Gravel, River Sand, Limestone Sand)				
RS 21-412-351	5.8	1430	7.0	143.3	17.9	5.3
		(Slag, Natural Sand, Mineral Filler)				
I 64-8(11)187	6.5	1440	8.0	138.0	17.0	4.2

GRADATION OF STOCKPILE AGGREGATES
(Type A Projects Sampled in 1964)

Aggregate	Percent Passing Sieve Size							
	1/2-in.	3/8-in.	No. 4	No. 8	No. 16	No. 50	No. 100	No. 200
LIMESTONE & NATURAL SAND								
				I 65-3(10)70				
No. 9 Limes.	100.0	91.2	21.8	0.7	0.4	0.4	0.4	0.4
Lime. Sand	100.0	100.0	100.0	92.4	65.2	30.6	19.4	12.8
Nat. Sand	100.0	100.0	99.4	90.1	75.4	14.6	8.1	4.9
				SP GROUP 6 (1964)				
No. 9 Limes	100.0	74.4	11.7	1.8	1.5	1.3	1.2	0.8
Limes. Sand	100.0	100.0	99.0	77.5	55.3	26.8	18.5	10.6
Nat. Sand	100.0	100.0	98.8	92.4	76.8	12.5	5.3	2.6
				SP 93-196				
No. 9 Limes.	100.0	87.5	19.8	4.9	3.5	3.0	2.8	1.3
Limes. Sand	100.0	100.0	99.3	71.5	44.2	23.1	17.6	12.3
Nat. Sand	100.0	100.0	99.2	90.2	75.0	26.3	16.8	11.4
				SP GROUP 8 (1964) (Sample 2)				
No. 9 Limes.	100.0	97.6	32.8	3.6	1.2	0.8	0.7	0.6
Limes. Sand	100.0	100.0	100.0	97.6	72.3	31.2	19.5	11.9
Nat. Sand	100.0	100.0	100.0	89.7	71.9	14.5	3.1	1.4
				SP 57-8-6				
No. 9 Limes.	100.0	95.3	37.9	8.8	3.7	1.9	1.7	1.6
Limes. Sand	100.0	100.0	96.7	86.6	69.7	37.8	28.5	22.2
Nat. Sand	100.0	100.0	100.0	90.2	73.2	14.8	1.7	0.7
				I 75-3(4) 87				
No. 9 Limes.	100.0	83.6	22.1	3.2	1.4	0.7	1.1	1.0
Limes. Sand	100.0	100.0	99.2	79.3	53.3	25.3	18.7	14.5
Nat. Sand	100.0	99.9	98.4	88.3	67.3	15.1	8.5	6.0
				F 220-11				
No. 9 Limes.	100.0	73.5	22.7	1.0	0.6	0.6	0.6	0.6
Limes. Sand	100.0	100.0	99.2	80.8	53.3	24.9	16.8	11.3
Nat. Sand	100.0	100.0	99.3	90.7	80.2	21.6	10.5	4.6
				I 64-8(10)183				
No. 9 Limes.	100.0	82.6	15.6	1.2	0.2	0.1	0.1	0.1
Limes. Sand	100.0	100.0	100.0	92.1	66.5	38.7	23.6	12.8
Nat. Sand	100.0	100.0	97.3	83.9	73.3	14.2	1.9	0.5
LIMESTONE, CRUSHED SANDSTONE, NATURAL SAND, MINERAL FILLER								
				SP 6-124-452				
No. 9 Limes.	100.0	90.2	18.9	2.5	1.6	1.1	0.9	0.8
Limes. Sand	100.0	100.0	99.6	83.9	59.2	26.1	15.8	9.3
Nat. Sand	100.0	100.0	99.4	91.5	72.4	14.1	4.7	3.0
Crushed S.S.	100.0	99.9	99.4	98.1	96.7	45.3	6.5	2.3
Mineral Filler	100.0	100.0	99.9	99.6	97.9	88.4	70.3	46.9
GRAVEL, NATURAL SAND, PIT SAND								
				RS 56-298-3				
No. 9 Gravel	100.0	91.9	35.9	6.9	2.6	1.9	1.7	1.6
Pit Sand	100.0	100.0	99.9	99.7	99.4	94.3	48.3	24.0
Nat. Sand	100.0	100.0	97.0	81.9	67.6	9.1	1.6	0.7
GRAVEL, PIT SAND, MINERAL FILLER								
				SP 50-55-7				
No. 9 Gravel	100.0	91.3	22.4	3.7	0.9	0.1	0.1	0.1
Nat. Sand	100.0	100.0	100.0	87.1	68.4	16.9	4.1	1.7
Mineral Filler	100.0	100.0	100.0	100.0	100.0	100.0	99.4	84.6
GRAVEL, NATURAL SAND, LIMESTONE SAND								
				RS 41-412-351				
No.9 Gravel	100.0	90.9	31.0	6.4	1.8	1.2	1.1	1.0
Limestone Sand	100.0	100.0	100.0	85.4	58.4	31.3	23.2	16.9
Nat. Sand	100.0	100.0	100.0	91.3	76.6	20.4	3.3	1.3
SLAG, NATURAL SAND, MINERAL FILLER								
				I 64-8 (11)187				
No. 9 Slag	100.0	89.4	16.2	1.6	1.2	0.8	0.6	0.5
Nat. Sand	100.0	100.0	97.2	84.6	74.1	18.3	2.5	0.7
Mineral Filler	100.0	100.0	100.0	100.0	100.0	100.0	99.6	88.2

SPECIFIC GRAVITY AND ABSORPTION OF AGGREGATES*
(Type A Projects Sampled in 1964)

Project Number	Specific Gravity			Absorption (%)		Virtual** Specific Gravity
	Bulk Oven Dry	Apparent	Sat.Sur. Dry	Water	Bitumen**	
	(Limestone Coarse Aggregate, Limestone and Natural Sand)					
I 65-3(10)70	2.62	2.69	2.68	1.1	0.0	2.57
SP GROUP 4(1964)	2.63	2.85	2.68	1.8	1.4	2.74
SP 93-196	2.64	2.76	2.68	1.6	0.3	2.62
SP GROUP 8(1964) (Sample 2)	2.61	2.73	2.65	1.4	1.5	2.71
SP 57-86	2.65	2.72	2.66	1.0	0.5	2.68
I 75-3(4)87	2.64	2.72	2.67	1.1	0.5	2.67
F 220(11)	2.64	2.69	2.66	0.5	1.2	2.62
I 64-8(10)183	2.60	2.67	2.63	1.1	1.0	2.68
	(Limestone, Crushed Sandstone, Natural Sand, Mineral Filler)					
SP 6-124-452	2.59	2.72	2.64	1.4	0.3	2.61
	(Gravel, River Sand, Pit Sand)					
RS 56-298-3	2.58	2.72	2.63	1.9	1.6	2.69
	(Gravel, Pit Sand, Mineral Filler)					
SP 59-55-7	2.63	2.72	2.72	1.3	0.6	2.68
	(Gravel, River Sand, Limestone Sand)					
RS 21-412-351	2.63	2.74	2.67	1.3	0.2	2.64
	(Slag, Natural Sand, Mineral Filler)					
I 64-8(11)187	2.45	2.71	2.55	2.5	1.3	2.54

* Specific gravity and water absorption values determined on the individual aggregates.

** Bitumen absorption and measured maximum theoretical specific gravity of paving mixtures (Rice's Method) determined as outlined in "Mix Design Methods for Asphalt Concrete," The Asphalt Institute, February, 1962.

GRADATION TEST RESULTS, EXTRACTED AGGREGATE
(Type A Mixtures Sampled in 1965)

Project Number	Percent Passing Sieve Size								
	1/2-in.	3/8-in.	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200
(Limestone and Natural Sand)									
SP 62-1	100.0	96.2	70.9	52.7	40.1	32.3	17.3	6.9	4.6
SP 14-13	100.0	98.3	72.1	52.5	42.4	34.2	18.4	6.5	3.7
SP GROUP 5(1965)	100.0	95.1	64.5	49.1	41.0	34.2	16.7	8.6	5.6
SP GROUP 9 (1965)	100.0	96.2	71.0	55.3	41.5	28.0	13.4	6.2	4.5
SP 32-49	100.0	96.8	73.8	55.2	44.1	33.7	14.8	5.7	3.9
SP 76-51	100.0	93.3	66.1	48.2	34.9	21.7	9.6	5.4	5.1
SP GROUP 10(1965)	100.0	96.7	72.0	51.4	36.9	25.0	9.9	3.7	3.3
SP GROUP 4(1965)	100.0	95.9	64.9	49.1	38.5	28.4	14.4	8.3	5.0
SP GROUP 1 (1965)	100.0	94.0	64.2	45.1	34.8	25.4	12.7	7.7	5.3
SP GROUP 3(1965)	100.0	96.0	68.6	57.2	45.4	32.8	17.0	8.7	6.3
RS GROUP 50(1965)	100.0	96.2	74.6	55.3	40.4	27.6	12.2	5.3	3.7
F 102(30)	100.0	95.4	68.5	48.6	40.7	39.6	15.7	6.8	3.7
SP GROUP 8(1965)	100.0	95.7	71.6	53.2	42.8	39.5	13.1	7.1	5.2
Average	100.0	95.8	69.5	51.8	40.2	31.0	14.2	6.7	4.6
Median	100.0	96.0	70.9	52.5	40.7	32.3	14.4	6.8	4.6
(Gravel Coarse Aggregate)									
SP GROUP 6(1965)	100.0	98.3	68.6	54.1	41.5	29.8	12.5	7.4	6.0
SP GROUP 34(1965)	100.0	96.5	74.8	54.2	40.5	27.4	11.7	4.8	4.2
SP GROUP 14(1965)	100.0	96.0	70.1	55.8	45.6	32.7	13.5	5.8	3.8
(Limestone Coarse and Fine)									
SP GROUP 18(1965)	100.0	94.9	68.8	46.1	30.6	23.8	15.1	10.1	7.7

EXTRACTION TEST RESULTS, SAMPLED MIXTURES
(Type A Mixtures Sampled in 1965)

Project Number	Sample	Asphalt Content (%) Design	Extraction
SP 62-1	A	5.7	6.0
	B		5.6
	C		5.9
SP 14-13	A	6.0	6.0
	B		5.7
	C		5.9
SP GROUP 5(1965)	A	5.4	5.7
	B		5.8
	C		5.8
SP GROUP 9(1965)	A	5.8	6.4
	B		6.5
	C		6.0
SP 32-49	A	5.7	5.5
	B		5.6
	C		5.4
SP 76-51	A	5.3	5.6
	B		5.1
	C		5.4
SP GROUP 10(1965)	A	5.7	5.3
	B		5.5
	C		5.2
SP GROUP 4(1965)	A	5.7	6.2
	B		5.8
	C		5.7
SP GROUP 1(1965)	A	5.6	5.8
	B		5.7
	C		5.7
SP GROUP 3(1965)	A	5.3	5.3
	B		5.3
	C		5.3
RS GROUP 50(1965)	A	5.5	5.4
	B		5.5
	C		5.6
F 102 (30)	A	5.7	5.3
	B		5.6
	C		5.3
SP GROUP 8(1965)	A	5.4	5.4
	B		5.5
	C		5.5
SP GROUP 6(1965)	A	5.2	4.9
	B		5.2
	C		5.5
RS GROUP 34(1965)	A	6.0	5.8
	B		5.7
	C		5.7
SP GROUP 14(1965)	A	5.8	6.0
	B		6.1
	C		6.0
SP GROUP 18(1965)	A	5.8	5.8
	B		6.0
	C		6.2

MARSHALL TEST RESULTS, SAMPLED MIXTURES, REHEATED
(Type A Mixtures Sampled in 1965)

Project Number	Asphalt Content Project Design (%)	Asphalt Content Extraction (%)	Stability (Lbs.)	Flow (0.01 in.)	Unit Weight (Lbs./Cu.Ft.)	Precent Agg.	Void Mix
		(Limestone and Natural Sand Aggregates)					
SP 62-1	5.7	5.8	2236	13	143.7	15.3	4.1
SP 14-13	6.0	5.9	1741	9	146.5	13.7	1.8
SP GROUP 5(1965)	5.4	5.8	1767	13	150.1	13.7	1.2
SP GROUP 9(1965)	5.8	6.3	1988	7	146.8	16.1	3.1
SP 32-49	5.7	5.5	1606	8	142.5	17.6	6.8
SP 76-51	5.3	5.4	1585	10	146.1	16.1	5.9
SP GROUP 10(1965)	5.7	5.3	1466	8	144.2	17.4	6.7
SP GROUP 4(1965)	5.7	5.9	2284	14	149.2	13.8	1.1
SP GROUP 1(1965)	5.6	5.7	2336	10	148.5	14.6	1.8
SP GROUP 3(1965)	5.3	5.3	2105	9	149.5	14.1	2.9
RS GROUP 50(1965)	5.5	5.5	1352	7	144.3	15.0	4.3
F 102(30)	5.7	5.4	1934	4	148.6	13.7	2.7
SP GROUP 8(1965)	5.4	5.5	2024	10	148.4	13.8	2.5
Average		5.6	1879	9	146.8	15.0	3.3
		(Gravel Natural Sand)					
SP GROUP 6(1965)	5.2	5.2	1475	8	144.4	16.2	5.5
		(Gravel, Natural Sand, Fly Ash)					
RS GROUP 34(1965)	6.0	5.7	1162	9	147.8	14.3	2.1
		(Gravel, Natural Sand, Mineral Filler)					
SP GROUP 14(1965)	5.8	6.0	1202	9	142.9	16.0	3.6
Average	5.7	5.7	1383	8	144.4	16.1	4.7
		(Limestone Coarse and Fine Aggregate)					
SP GROUP 18(1965)	5.8	6.0	2549	21	153.2	12.1	1.2

AGGREGATE GRADATIONS, MARSHALL DESIGNS
(Type A Projects Sampled in 1965)

Project Number	Percent Passing Sieve Size							
	1/2-in.	3/8-in.	No. 4	No. 8	No. 16	No. 50	No. 100	No. 200
SP 62-1	100.0	93.7	67.9	52.4	40.3	15.4	5.7	3.6
SP 14-13	99.9	95.7	71.8	52.7	41.7	17.8	7.2	4.3
SP GROUP 5(1965)	100.0	88.8	62.2	51.9	42.8	15.2	7.8	4.3
SP GROUP 9 (1965)	100.0	95.1	71.5	55.3	41.6	14.1	7.2	4.8
SP 32-49	100.0	97.0	71.1	53.6	44.3	14.5	5.8	4.2
SP GROUP 6(1965)	100.0	95.5	66.1	53.5	42.0	11.8	6.3	5.0
SP 76-51	100.0	88.4	60.0	50.1	39.6	8.6	5.6	4.6
SP GROUP 10(1965)	100.0	91.3	61.1	49.6	39.3	11.2	4.6	3.2
RS GROUP 34(1965)	100.0	97.1	72.2	52.5	41.2	12.9	6.1	4.6
SP GROUP 4(1965)	100.0	96.8	67.6	49.0	38.3	13.5	7.7	4.6
SP GROUP 1(1965)	100.0	90.5	61.6	47.5	35.6	10.3	5.6	3.4
SP GROUP 3(1965)	100.0	95.1	67.2	55.4	45.6	17.7	9.0	6.3
SP GROUP 14(1965)	100.0	93.8	70.0	58.5	45.8	13.1	6.3	4.3
RS GROUP 50(1965)	100.0	96.7	66.5	52.6	43.0	13.7	4.9	3.4
F 102(30)	100.0	95.6	67.4	49.5	41.6	16.3	6.8	3.7
SP GROUP 18(1965)	100.0	94.3	62.0	44.5	32.3	16.4	11.0	8.0
SP GROUP 8(1965)	100.0	96.5	71.9	53.5	42.6	11.9	6.3	4.6

LABORATORY RESULTS, MARSHALL DESIGNS
(Type A Projects Sampled in 1965)

Project Number	Optimum Asphalt Content (%)	Stability (Lbs.)	Flow (0.01 in.)	Unit Weight (Lbs./Cu.Ft.)	Percent Voids Agg.	Mix
		(Limestone and Natural Sand)				
SP 62-1	5.9	1950	6	144.3	14.9	3.3
SP 14-13	5.6	1890	7	146.4	13.4	2.1
SP GROUP 5(1965)	5.2	1740	8	150.1	13.1	2.2
SP GROUP 9(1965)	5.2	2360	8	150.3	13.0	2.4
SP 32-49	5.8	1650	7	146.4	15.6	3.6
SP 76-51	5.8	1600	6	148.2	15.4	3.9
SP GROUP 10(1965)	5.6	1710	6	148.8	15.2	3.3
SP GROUP 4(1965)	5.4	2230	9	148.8	13.7	2.2
SP GROUP 1(1965)	5.5	1620	6	146.0	15.9	4.0
SP GROUP 3(1965)	5.0	2450	10	149.8	13.7	3.2
RS GROUP 50(1965)	5.7	1170	5	145.8	14.2	3.0
F 102(30)	5.6	2060	6	147.8	14.4	3.1
SP GROUP 8(1965)	5.9	1430	6	147.2	15.1	2.7
Average	5.6	1835	7	147.7	14.4	3.0
		(Gravel Coarse Aggregate)				
SP GROUP 6(1965)	5.7	1320	6	147.2	14.6	2.8
RS GROUP 34(1965)	5.1	1190	5	148.0	13.6	3.0
SP GROUP 14(1965)	5.9	900	6	142.3	16.2	4.1
		(Limestone Coarse and Fine)				
SP GROUP 18(1965)	4.9	2440	11	151.9	11.7	1.2

GRADATION OF STOCKPILE AGGREGATES
(Type A Surfacing Projects Sampled in 1965)

Aggregate Type	Percent Passing Sieve Size 1/2-in.	3/8-in.	No. 4	No. 8	No. 16	No. 30	No. 50	No.100	No. 200
SP 62-1									
No. 9 Limes.	100.0	84.9	23.9	4.9	2.4	2.1	1.9	1.8	1.6
Nat. Sand	100.0	99.9	99.8	87.7	75.1	63.8	23.0	2.1	1.0
Limes. Sand	100.0	100.0	99.6	85.4	57.6	40.9	28.2	17.4	10.8
SP 14-13									
No. 9 Limes.	100.0	89.2	27.2	5.9	5.0	3.0	2.7	2.4	2.1
Nat. Sands	99.9	99.5	98.7	81.3	68.2	57.0	26.8	5.8	2.0
Limes. Sand	100.0	100.0	100.0	81.6	56.8	39.6	27.7	18.4	12.4
SP GROUP 5(1965)									
No. 9 Limes.	100.0	74.5	15.4	0.6	0.3	0.3	0.3	0.3	0.3
Nat. Sand	100.0	100.0	98.1	92.9	87.5	74.9	17.0	3.1	1.2
Limes. Sand	100.0	100.0	100.0	89.7	56.0	37.6	27.3	18.8	12.5
Limes. Dust	100.0	100.0	100.0	100.0	99.4	96.4	84.4	53.8	22.7
SP GROUP 9(1965)									
No. 9 Limes.	99.9	85.7	14.2	1.0	0.7	0.7	0.7	0.7	0.6
Nat. Sand	100.0	100.0	99.6	86.0	67.4	44.4	16.1	4.7	2.6
Limes. Sand	100.0	100.0	99.8	79.2	55.3	39.3	28.9	19.6	13.9
SP 32-49									
No. 9 Limes.	100.0	93.7	40.7	11.1	6.1	4.4	3.6	3.0	2.7
Nat. Sand	100.0	100.0	97.1	90.7	84.2	69.0	19.1	1.3	0.8
Limes. Sand	100.0	100.0	100.0	92.1	68.1	48.0	32.7	20.1	12.9
SP 76-51									
No. 9 Limes.	100.0	72.3	6.1	2.5	2.4	2.4	2.4	2.4	2.2
Nat. Sand	100.0	100.0	98.2	90.3	77.8	48.0	5.0	0.5	0.4
Limes. Sand	100.0	100.0	99.8	76.2	50.4	34.1	24.6	18.2	15.2
SP GROUP 10 (1965)									
No. 9 Limes.	100.0	81.0	18.4	1.7	0.9	0.7	0.5	0.4	0.4
Nat. Sand	100.0	100.0	99.9	87.3	69.3	47.9	14.7	2.7	1.3
Limes. Sand	100.0	100.0	100.0	99.6	79.8	55.0	36.2	23.4	17.8
SP GROUP 4 (1965)									
No. 9 Limes.	100.0	93.3	34.0	6.1	2.7	2.1	1.8	1.5	1.3
Nat. Sand	100.0	100.0	97.5	88.3	77.4	57.3	19.3	8.3	3.1
Limes. Sand	100.0	100.0	100.0	89.1	62.8	44.2	30.8	20.3	13.9
SP GROUP 1 (1965)									
No. 9 Limes.	100.0	79.3	18.0	4.1	2.9	2.4	2.0	1.7	1.5
Nat. Sand	100.0	100.0	97.4	88.2	78.2	59.4	14.0	3.5	1.2
Limes. Sand	100.0	100.0	99.8	80.2	47.5	29.7	21.0	14.5	9.4
SP GROUP 3 (1965)									
No. 9 Limes.	100.0	88.4	22.2	6.2	3.4	2.5	2.1	1.9	1.7
Nat. Sand	100.0	100.0	100.0	89.8	74.5	54.6	19.6	3.3	1.5
Limes. Sand	100.0	100.0	99.3	93.4	79.4	62.2	47.0	34.4	25.0
RS GROUP S0 (1965)									
No. 9 Limes.	100.0	91.9	21.2	2.6	1.8	1.4	1.1	0.9	0.7
Nat Sand	100.0	100.0	97.6	85.6	72.3	55.3	16.4	0.6	0.3
Limes. Sand	100.0	100.0	97.9	88.6	63.1	38.2	18.8	6.9	3.7
Min. Filler	100.0	100.0	100.0	100.0	100.0	99.2	95.4	79.8	60.4
I 65-3(10) 70									
No. 9 Limes.	100.0	87.7	20.9	2.1	1.6	1.5	1.3	1.1	1.0
Nat. Sand	100.0	100.0	98.7	89.0	77.0	57.6	22.0	9.4	4.2
Limes. Sand	100.0	100.0	99.6	94.7	80.6	61.7	41.4	24.6	16.0
F-102(30)									
No. 9 Limes.	100.0	90.4	30.5	4.7	2.6	2.4	2.1	1.8	1.6
Nat. Sand	100.0	100.0	98.1	88.0	80.3	73.8	25.2	8.1	2.8
Limes. Sand	100.0	100.0	100.0	86.8	65.5	59.0	33.5	16.2	9.8
SP 56-633									
No. 9 Limes.	100.0	87.9	24.3	4.8	4.0	3.9	3.4	3.1	2.5
Nat. Sand	100.0	100.0	97.5	86.6	74.8	65.4	23.2	7.8	2.8
Limes. Sand	100.0	100.0	100.0	82.0	58.6	48.3	31.0	21.0	14.4
SP GROUP 8 (1965)									
No. 9 Limes.	100.0	91.7	36.1	7.7	3.8	2.5	2.1	1.8	1.6
Nat. Sand	100.0	100.0	96.7	86.0	71.9	48.6	8.2	0.4	0.2
Limes. Sand	100.0	100.0	100.0	84.7	61.4	42.6	27.9	16.0	10.6
Min. Filler	100.0	100.0	99.8	99.1	97.8	95.2	84.5	67.1	52.4
SP GROUP 6 (1965)									
No. 9 Gravel	100.0	87.8	17.0	3.9	1.8	1.4	1.2	1.0	1.0
Nat. Sand	100.0	100.0	95.4	80.1	67.7	48.4	10.0	2.0	1.4
Gravel Sand	100.0	100.0	94.1	86.7	62.5	43.2	29.4	20.2	16.3
RS GROUP 34 (1965)									
No. 9 Gravel	100.0	93.1	34.5	4.2	1.2	0.7	0.5	0.3	0.2
Nat. Sand	100.0	100.0	99.5	86.4	67.9	44.7	16.3	4.2	2.1
Fly Ash	100.0	100.0	100.0	100.0	100.0	99.5	98.0	93.7	84.1
SP GROUP 14 (1965)									
No. 9 Gravel	100.0	80.6	15.7	3.8	3.0	2.8	2.5	2.0	1.3
Nat. Sand	100.0	100.0	93.8	83.4	66.8	34.5	10.4	0.6	0.1
Gravel Sand	100.0	100.0	100.0	83.1	54.2	34.4	20.4	10.6	6.9
Min. Filler	100.0	100.0	100.0	100.0	100.0	100.0	99.5	92.5	72.2
SP GROUP 18 (1965)									
No. 9 Limes	100.0	89.6	30.9	6.3	3.6	3.4	2.4	2.0	1.7
Limes. Sand	100.0	100.0	100.0	91.0	67.4	54.9	33.6	21.9	15.7

SPECIFIC GRAVITY AND ABSORPTION OF AGGREGATES*
(Type A Projects Sampled in 1965)

Project Number	Specific Gravity			Absorption (%)		Virtual** Specific Gravity
	Bulk Oven Dry	Apparent	Sat.Sur. Dry	Water	Bitumen**	
	(Limestone Coarse Aggregate, Limestone and Natural Sand)					
SP 62-1	2.54	2.72	2.61	2.1	1.0	2.63
SP 14-13	2.56	2.71	2.61	1.8	0.8	2.62
SP GROUP 5(1965)	2.63	2.72	2.66	1.2	0.6	2.67
SP GROUP 9(1965)	2.62	2.73	2.66	1.2	0.8	2.68
SP 32-49	2.62	2.69	2.64	0.9	0.8	2.67
SP 76-51	2.64	2.72	2.67	1.1	1.0	2.71
SP GROUP 10(1965)	2.65	2.73	2.68	1.0	0.7	2.70
SP GROUP 4(1965)	2.61	2.72	2.64	1.3	0.6	2.65
SP GROUP 1(1965)	2.62	2.69	2.66	1.4	0.4	2.65
SP GROUP 3(1965)	2.66	2.73	2.66	1.2	0.6	2.69
RS GROUP 50(1965)	2.57	2.69	2.62	1.6	0.9	2.63
F 102(30)	2.61	2.72	2.65	1.6	0.8	2.66
SP GROUP 8(1965)	2.61	2.70	2.64	1.3	0.7	2.66
	(Gravel Coarse Aggregate, Natural Sand)					
SP GROUP 6(1965)	2.61	2.73	2.65	1.5	0.6	2.66
RS GROUP 34(1965)	2.63	2.72	2.68	1.8	0.6	2.65
SP GROUP 14(1965)	2.56	2.68	2.60	1.3	0.6	2.60
	(Limestone Coarse and Fine Aggregate)					
SP GROUP 18(1965)	2.63	2.73	2.66	1.4	0.6	2.67

* Specific gravity and water absorption values determined on the individual aggregates.

** Bitumen absorption and measured maximum theoretical specific gravity of paving mixtures (Rice's Method) determined as outlined in "Mix Design Methods for Asphalt Concrete," The Asphalt Institute, February, 1962.